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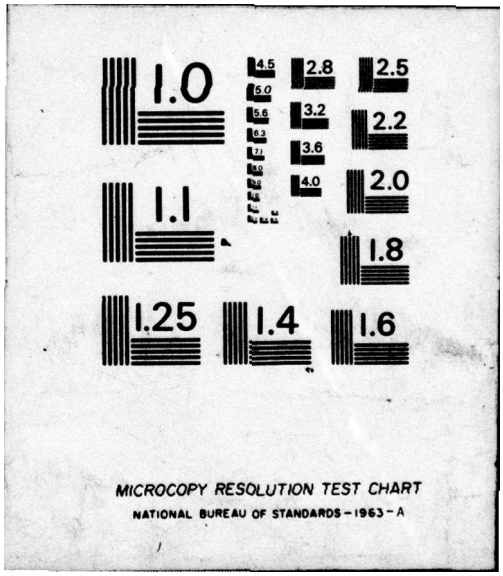
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Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME I
NUMBER 1
OCTOBER, 1976

A DIGEST OF CURRENT LITERATURE

A Quarterly Publication
Produced for
Office of Telecommunications Policy
and
United States Navy

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13. ABSTRACT

Biological Effects of Nonionizing Electromagnetic Radiation is a publication researched and prepared by the Franklin Institute Research Laboratories, under a contract with the U.S. Navy and administered by the Office of Telecommunications Policy.

This digest serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and radiofrequency radiation) are compiled, condensed, and disseminated on a regular basis. It is intended to be a highly useful current awareness tool for scientists engaged in research or related activities. The great number and diversity of relevant publication make imperative the availability of this service to persons whose work requires that they keep abreast of current developments in the field.

Biological Effects of Nonionizing Electromagnetic Radiation is published quarterly. The issues of Volume 1, and future volumes, will include materials received during the preceding three months. Each issue will include news items and announcements, a listing of meetings and conferences, abstracts of current literature, and a directory of current research. Materials for which full text is not available will be included as summary abstracts.

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Non-Ionizing Radiation						
Microwave Radiation						
Electric Fields						
Magnetic Fields						

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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION.

Volume 1. Number 1.

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(10) Bruce H. Kleinstein
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(12) 48p.

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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

October, 1976 Volume 1, Number 1

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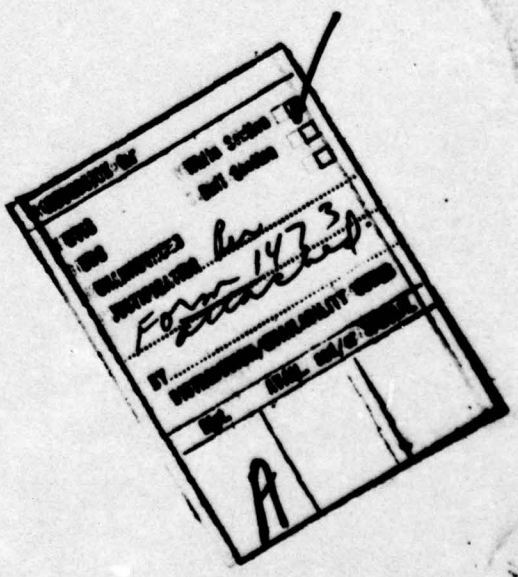

PREFACE

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This digest serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and radiofrequency radiation) are compiled, condensed, and disseminated on a regular basis. *Biological Effects of Nonionizing Electromagnetic Radiation* is intended to be a highly useful current awareness tool for scientists engaged in research or related activities. The great number and diversity of relevant publications make imperative the availability of this service to persons whose work requires that they keep abreast of current developments in the field.

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ABBREVIATIONS AND ACRONYMS

A, amp - ampere
BRH - Bureau of Radiological Health
C - centigrade
cm - centimeter
cps - cycles per second
dB - decibel
EPA - Environmental Protection Agency
ERDA - Energy, Research and Development Agency
FDA - Food and Drug Administration
g - gram
G - Gauss
GHz - gigahertz
HEW - Health, Education, and Welfare
hr - hour
Hz - hertz
IEEE - Institute of Electronic and Electrical Engineers
IMPI - International Microwave Power Institute
IU - international units
J - joule
k - kilo--
l - liter
m - meter
m - milli--
M - mega--
mho - unit of measurement of conductivity
min - minute
mo - month
NBS - National Bureau of Standards
NIH - National Institutes of Health
nm - nanometer
NSF - National Science Foundation
NIOSH - National Institute for Occupational Safety and Health
NTIS - National Technical Information Service
Oe - oersted
OSHA - Occupational Safety and Health Administration
OTP - Office of Telecommunications Policy
PHS - Public Health Service
rad - radiation absorbed dose
R - Roentgen
rpm - revolutions per minute
sec - second
UHF - ultra high frequency
USAFSAM - U.S. Air Force School of Aerospace Medicine
USDA - U.S. Department of Agriculture
UV - ultraviolet
VA - Veterans Administration
W - watt
WHO - World Health Organization
wt - weight
yr - year

NEWS ITEMS

WHAT LEADS A TERMITE THROUGH A MAGNETIC FIELD?

Dr. Gunther Becker, one of the world's leading experts on termites claims that termites possess a natural ability to detect weak electric and magnetic fields. This ability would account, in part, for termites' remarkable social organization. A reaction to the earth's magnetic field has been suspected for some time, since it has been observed that certain termite mounds are flattened vertically along an E/W direction. To demonstrate the influence of alternating magnetic fields on termites, Becker placed a small plastic container of termites more than 3 m away from a room heater generating a 50 Hz field. Although the field was of such low intensity that it could only be measured up to 10 cm from the source, the termites built vertical galleries at the edges farthest away from the source. The termites must therefore have been able to perceive the minute differences in the strength of the alternating magnetic field within the confines of their container. Another experiment showed that termites can influence each other by their own "biofields". Becker demonstrated that termites were able to communicate through 5 mm of plastic foam but could not communicate when shielded by 5 mm of aluminum. Becker believes biofields are probably alternating electric fields enabling termites to construct galleries at the borders of nesting areas where the insects need to forage. Such biofields would enable termites to avoid serious competition for food. Becker's research poses the question as to whether one could put a magnetic field around a house to protect it from termite damage.

New Scientist 71(1014): 391; 1976

MICROWAVE EXPOSURE LEVELS FROM MARINE RADAR EVALUATED

The Division of Electronic Products of the Bureau of Radiological Health has conducted a study of the range and magnitude of microwave radiation exposure resulting from marine radar units used on small pleasure boats. Investigators surveyed 33 marine radar units in actual use and compiled information concerning 43 different models. Laboratory measurements were performed in the Division's anechoic chamber, and calculated emission levels were compared with experimentally measured values. According to a recently published report on the study, personnel exposure to microwave emissions from the radar units probably will not exceed 1 mW/cm^2 average power density under normal operating conditions. However, significantly increased emission levels might be encountered if a unit is operated with the antenna rotation stopped. The report recommends that exposure under such conditions be avoided. Another finding was that instantaneous peak microwave emissions in the region surrounding the antenna might be quite high. Although any possible biological hazards associated with these emission levels are uncertain at present, the possibility of interference phenomena in critical devices, such as cardiac pacemakers, seems to warrant caution. Therefore, the report suggests that care be exercised to limit the unnecessary use of marine radar in areas of high population density--for example, when docked in harbor. The U.S. Coast Guard has reviewed the report and has agreed to a program of cooperation with the Bureau on the safety aspects of marine radar. The report is available from the National Technical Information Service, as indicated under "New Bureau Publications."

BRH Bulletin 10(1): 3-4; 1976

VISITING SCIENTIST JOINS BUREAU STAFF

Dr. Przemyslaw Cerski has accepted an appointment with the Bureau of Radiological Health to work with the Division of Biological Effects on a program to determine the effects of microwaves on the blood-forming system. He comes to the Bureau from Poland's National Research Institute of Mother and Child where he is a Professor of Genetics and Head of the Department of Human Genetics. This department has been designated a World Health Organization Collaborating Center for Bioeffects of Nonionizing Radiation, and Dr. Czerski serves as the Center's Head. He also has served as adviser on nonionizing radiation protection to the Polish Ministry of Health and Social Welfare.

BRH Bulletin 10(1): 2; 1976

MICROWAVE SAFETY LEVEL STILL TOO HIGH?

In experiments performed for the Environmental Protection Agency, Dr. Andrew Huang of Duke University Medical Center has detected changes in the white blood cells of hamsters exposed to microwave doses as low as 5 mW/cm^2--half the maximum dose set by Food and Drug Administration regulations for microwave ovens. Huang exposed hamsters to 15 minutes of microwave radiation (at 2.45 and 9.00 GHz) per day for seven days. The ability of the animal's lymphocytes to transform into antibody forming cells, when stimulated in the test tube, was impaired by the microwave radiation. This preliminary experiment raises the possibility that the immune response of hamsters to infection is likely to be decreased as a result of microwave radiation exposure. Huang has become seriously concerned about the safety of the rapidly growing number of microwave ovens now being sold in the U.S. He believes that if what he finds true in hamsters is true in humans, existing ovens could pose a potential threat in the home. Ironically, the radiation levels in a typical kitchen equipped with a microwave oven far exceed those recently beamed into the U.S. Embassy in Moscow, which, it was feared, endangered the health of Embassy employees.

New Scientist 69(987): 323; 1976

EFFECTS OF MICROWAVE ON THE NERVOUS SYSTEM

A contract in the amount of $176,065 has been awarded to the University of Utah, Salt Lake City, by the National Institutes of Health, Bethesda, Maryland, to study the effects of chronic exposure to low intensity (5 mW/cm^2) microwave radiation on rat behavior, EEG, and blood and urine biochemistry. The animals will be irradiated eight hours per day, in five-day per week sessions at 915 and 2450 MHz. The project, under the direction of Dr. Om Gandhi, will try to answer questions on the disparate safety levels of radiation followed in the U.S. and the Eastern-block countries. The work will be performed jointly with the University of Washington, Seattle.

Utah Bioengineering Newsletter 3(5): 1-2; 1976

ITEMS FROM THE COMMERCE BUSINESS DAILY

☐ **FURTHER RESEARCH ON THE NEUROPHYSIOLOGICAL AND BEHAVIORAL EFFECTS OF CONTINUED WAVE AND PULSED MICROWAVES IN RODENTS AND OTHER LABORATORY ANIMALS.**

The Office of Naval Research, Arlington, Virginia, has contracted with the Board of Regents of the University of Washington, Seattle, for the above study. (January 30, 1976)

☐ **INVESTIGATION OF ELECTRIC FIELDS.**

The National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Texas, has contracted with the Stanford Research Institute, Menlo Park, California, for the above study. (August 11, 1976)

☐ **EXPANSION OF STUDY ON THE EFFECTS OF MICROWAVE RADIATION ON THE CENTRAL NERVOUS SYSTEM.**

The Department of Health, Education, and Welfare, Food and Drug Administration, Rockville, Maryland, has contracted with George Washington University, Washington, D.C., for the above study. (July 21, 1976)

☐ **RESEARCH ON MICROWAVE BIOTISSUES.**

The University of Maryland, College Oaks, will perform the above study. (July 2, 1976)

MICROWAVE/RADIOFREQUENCY BIOEFFECTS BIBLIOGRAPHY

The eighth supplement to the "Bibliography of Reported Biological Phenomena ('Effects') and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation," published in August 1976, is available from the National Technical Information Service (Springfield, VA 22151) as AD 734-391. This report, prepared by Dr. Zorach R. Glaser and Patricia F. Brown of the Naval Medical Research Institute Detachment, Naval Surface Weapons Center/Dahlgren Laboratory, Dahlgren, Virginia, contains approximately 350 references. Particular attention is paid to the effects of microwave and radiofrequency radiation on man.

AD 734-391; August 1976

MEETINGS AND CONFERENCES

OPERATIONAL HEALTH PHYSICS SYMPOSIUM

Date: February 9-12, 1976
Place: Denver, Colorado
Sponsor: Health Physics Society
Requests for Information: Mr. J. B. Martin, P.O. Box 3229, Boulder, Colorado 80303

MICROWAVE POWER SYMPOSIUM 1976

Date: July 27-30, 1976
Place: Louvain, Belgium
Sponsor: International Microwave Power Institute
Requests for Information: Mr. V. Decareau, P.O. Box 247, Amherst, New Hampshire 03037

EUROPEAN MICROWAVE CONFERENCE

Date: September 14-17, 1976
Place: Rome, Italy
Sponsor: Italian Association of Electrical and Electronics Engineers
Requests for Information: Microwave Exhibitions and Publishers Ltd., Temple House, 36 High St., Sevenoaks, Kent TN13 1JG, England

INTERNATIONAL IEEE ANTENNAS AND PROPAGATION SYMPOSIUM

Date: October 11-15, 1976
Place: Amherst, Massachusetts
Sponsor: IEEE, URSI
Requests for Information: R. E. McIntosh, Electrical and Computer Engineering Department, University of Massachusetts, Amherst, Massachusetts 01002

Selected Bibliography of Papers Presented:

LYMPHOCYTE TRANSFORMATION INDUCED BY MICROWAVE RADIATION. A. T. Huang (Dept. Medicine, Duke Univ. Medical Center, Durham, NC), M. E. Engle and J. A. Elder.

EFFECTS OF PULSED MICROWAVES ON THE HEMATOPOIETIC SYSTEM OF MICE. H. A. Ragan (Biology Dept., Battelle, Pacific Northwest Lab., Richland, WA 99352) and R. D. Phillips.

LOW INTENSITY MICROWAVE EFFECTS ON THE SYNTHESIS OF THYROID HORMONES AND SERUM PROTEINS. W. D. Travers (Bionucleonics Dept., Sch. Pharmacy and Pharmacal Sciences, Purdue Univ., West Lafayette IN 47907) and R. J. Vetter.

CAN ELECTROMAGNETIC WAVES CAUSE CONGENITAL ANOMALIES? R. Rugh (U.S. Dept. Health, Education, Welfare, Public Health Service, Food, Drug Admin., Bureau Radiological Health, Rockville, MD) and M. McManaway.

MICROWAVE-INDUCED TERATOLOGY IN THE RAT. M. E. Chernovetz (Tulsa Univ., Tulsa, OK), A. F. Oke, and D. R. Justesen.

THE EFFECT OF REPEATED MICROWAVE EXPOSURE IN NEONATAL RATS. R. Guillet (Dept. Radiation Biology and Biophysics, Sch. Medicine and Dentistry, Univ. Rochester, Rochester, NY) and S. Michaelson.

RADIOLOGICAL SOCIETY OF NORTH AMERICA SCIENCE ASSEMBLY AND ANNUAL MEETING

Date: November 14-19, 1976
Place: Chicago, Illinois
Sponsor: RSNA
Requests for Information: Ms. A. Swenson, Executive Director, Radiological Society of North America, 15th Floor, One Mony Plaza, Syracuse, New York 13202

NATIONAL TELECOMMUNICATIONS CONFERENCE

Date: November 29 through December 1, 1976
Place: Dallas, Texas
Sponsor: IEEE
Requests for Information: J. H. Tilley, Collins Radio Company, North Alma Road, Richardson, Texas 75080

THE CHEMICAL SOCIETY SYMPOSIUM ON NEWER ASPECTS OF MOLECULAR RELAXATION PROCESSES

Date: December 13-14, 1976
Place: London, United Kingdom
Sponsor: The Chemical Society (Faraday Division) [U.K.]
Requests for Information: Mrs. Y. A. Fish, Faraday Division, The Chemical Society, Burlington House, London, W1V OBN, United Kingdom

INTERNATIONAL RADIATION PROTECTION CONGRESS

Date: April 24-30, 1977
Place: Paris, France
Sponsor: IRPA
Requests for Information: G. Bresson, BP 33, 92260-Fontenay-aux-Roses, France

MICROWAVE POWER SYMPOSIUM 1977

Date: May 25-28, 1977
Place: Minneapolis, Minnesota
Sponsor: International Microwave Power Institute
Requests for Information: Mr. O. P. Snyder, University of Minnesota, Department of Food Science and Nutrition, Saint Paul, Minnesota 55108

IEEE-MIT INTERNATIONAL MICROWAVE SYMPOSIUM

Date: June 21-23, 1977
Place: San Diego, California
Sponsor: IEEE
Requests for Information: R. Casey, Code 1300, NELC, San Diego, California 92152

ELECTROMAGNETIC COMPATIBILITY SYMPOSIUM AND EXHIBITION

Date: June 28-30, 1977
Place: Montreux, Switzerland
Sponsor: Swiss PTT
Requests for Information: Mr. T. Dvorak, Hochfrequenztechnik, 8092 ETH Zurich, Switzerland

ENGINEERING IN MEDICINE AND BIOLOGY CONFERENCE

Date: November 5-9, 1977
Place: Los Angeles, California
Sponsor: Alliance for Engineering in Medicine and Biology
Requests for Information: Mrs. P. I. Horner, Assistant Director and Conference Coordinator, Alliance for Engineering in Medicine and Biology, Suite 1350, 5454 Wisconsin Ave., Chevy Chase, Maryland 20015

0001 RADIOFREQUENCY RADIATION INTERFERENCE (RFI) OF MEDICAL PROSTHETIC DEVICES. Mitchell, J. C.; Hardy, K. A. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

This study is aimed at developing test data on the interaction of Air Force radiofrequency radiation emitters and medical prosthetic devices. The initial objective is to assess manufacturers' progress in developing cardiac pacemakers to operate properly pulsed radiofrequency fields of 200 V/m. The overall purpose of this research and development effort is to resolve the potential hazard to cardiac pacemaker users in the vicinity of radiofrequency radiation emitters. A state-of-the-art test sample of cardiac pacemakers including approximately 20 types made by 10 different manufacturers will be tested to a variety of radiofrequency radiation sources. Tests will be conducted in both "free-field" and "simulated-implant" configurations, in the laboratory, and at radar and communication sites remote from Brooks Air Force Base. Test plans include studies using the AWACS radar, AN/FPS-24 and 35 research radar, AN/MPS-T1 ECM threat simulators, AN/FRT-49 ground to air telemetry system, and a LORAN system. The AN/FPS-85 and and AN/TPS-44 may also be studied. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0002 NONIONIZING ELECTROMAGNETIC RADIATION INTERACTION WITH CENTRAL NERVOUS SYSTEM CNS FUNCTION (ABBREV). Diachenko, J. A.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

Nonionizing, electromagnetic radiation may interact with the central nervous system. However, the course, character, and extent of central nervous system interaction has not been clearly defined. Neuromuscular microtremor measured at the fingertip offers a sample of central nervous system function. The literature amply demonstrates that normal human tremor (typically measured with the finger pressed upon a transducer) exhibits a major peak neuromuscular frequency between 8-12 Hz, and where the central nervous system has been acted upon by toxic substances, the tremor typically shifts to a lower frequency below 8 Hz. Workers exposed to electromagnetic radiation will be studied via microtremor sampling to investigate changes in central nervous system function and to obtain a better definition of the onset and course of electromagnetic interaction. A tremor sensing device has been built and used to obtain samples from workers exposed to electromagnetic radiation and from control personnel. Testing does not involve intentional exposure of subjects to electromagnetic radiation. Samples are obtained from electromagnetic radiation-exposed workers before and after any exposure encountered in their normal work and consist of analog recordings from the fingertip as it presses a sensitively balanced transducer. The transducer forms one side of a balanced bridge circuit such that minute force changes on the transducer cause larger unbalanced voltages within the bridge, thus obtaining a direct translation of finger vibrations (tremor) into voltage shifts. These voltage changes are analyzed through a fourier spectrum analyzer, which yields power spectra for each 2 minute sample—literally a sorting of frequencies with attendant power. This power spectrum offers visual evidence of the normal tremor peak between 8-12 Hz. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0003 CARDIOVASCULAR EFFECTS OF MULTIFREQUENCY MICROWAVE RADIATION. Reno, V. R.; Beischer, D. E. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

Laboratory experiments will be conducted to evaluate the effects of operational microwave exposure of naval personnel. This study is part of an approach that involves considerations of dosimetry, scaling and frequency specificity as related to the observed changes in the electrocardiogram (ECG). Subhuman primates will be exposed to microwave radiation in the range of 1-30 mW/cm^2 for extended periods. Vertically or horizontally polarized radiation will be used at selected frequencies between 1 and 12.4 GHz to characterize frequency and polarization specific effects. Changes in cardiac performance will be determined by computer analysis of the ECG and correlated with the various radiation parameters. The results from these experiments will be integrated with those from studies under the same conditions to provide more complete insight into the biological effects of microwave radiation. This new work unit continues previously performed research. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0004 PROGRAM ON THE QUANTITATION OF THE EFFECTS OF ELECTROMAGNETIC ENERGY ON HUMAN TISSUE. Guy, A. W. (Univ. Washington, Medical Rehabilitation Research & Training Center, 15th Ave. N.E., Seattle, WA 98105).

The purpose of this investigation is to advance the existing knowledge on the human body and to provide realistic guidelines for safety standards of human exposure. The electromagnetic field patterns from external sources of energy, both in and exterior to the tissues of human subjects and test animals, will be established quantitatively. The test animals will be exposed to the various continuous wave and modulated electromagnetic sources at both thermal and nonthermal lower levels while monitoring the energy in the tissues. The physiological and behavioral characteristics of the animals will be observed before, during, and after exposure to electromagnetic radiation. The time and power density thresholds for cataract production will be determined in animals exposed to microwave radiation. Safe human exposure levels will be determined, taking into proper account the source, configuration, frequency, and location. The theoretical analysis involves the solution of Maxwell's equation for the absorbed power by biological systems for a host of different geometries. The experimental studies involve controlled exposure of test animals to select sources of electromagnetic energy with the aim of quantifying observable effects and changes on the biological systems. Thus far, the minimum catar-

actogenic threshold in the eye of a rabbit exposed to electromagnetic energy has been determined. The threshold for human auditory perception of incident microwave pulses was found to correspond to a specific pulse energy density regardless of average or peak power. Calculated peak pressures induced in mammalian tissues by the incident electric field energy were found to be above the bone-conduction threshold. The behavior of the spinal cord exposed to high level microwaves indicates that this central nervous system structure is subject to functional alteration by the impingement of radiation. These effects are not unique; they are the same as the effects of nonradiation heating. If the tissues are properly cooled during microwave illumination, the effects are ameliorated or even reversed. The effect of radiating the abnormally cold spinal cord with microwaves is to change the activity in the direction toward normalcy. (7/75-6/76)

Supporting Agency:HEW, Social & Rehabilitation Serv., Office of Res. Demons. & Trng., Res. & Trng. Centers Div.

0005 INTERACTION OF ELECTROMAGNETIC FIELD WITH HUMAN BODY. Chen, K. (Michigan State Univ., Sch. Engineering, Engineering Building, East Lansing, MI 48824).

This research program will concentrate on the interaction of an electromagnetic field with the human body. A theoretical study will be conducted to determine the internal electromagnetic field induced inside the body and the external electromagnetic wave scattered by the body when it is illuminated by an electromagnetic wave. The accuracy of the theoretical results will be verified by an experimental study that will be conducted to measure the electric fields induced inside of simple boxes containing saline solution and inside the phantom model, which closely approximates the actual human tissues and torso. The theoretical method involves the numerical solution of a tensor integral equation for the electric field induced inside an irregularly shaped body. Various models of the human torso or other biological systems will be considered. It is anticipated that after the accuracy of the theoretical method is established a user-oriented computer program for the field calculations will be developed. (8/75-7/76)

Supporting Agency:U.S. Natl. Sci. Found., Div. Eng.

0006 BIOLOGICAL EFFECTS OF LOCALIZED E- AND H-FIELDS IN THE STANDING MICROWAVE FIELD. Beischer, D. E.; Reno, V. R. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

Standing waves are found on board ship due to microwave reflections from metal walls and equipment. The effects of localized E- and H-fields on living objects will be investigated. Electric (E) and magnetic (H) fields will be generated at different microwave frequencies by reflection of a traveling wave from a metal plate in an anechoic chamber. Measurements based on previous experience will provide information on the degree of local separation of the E- and H-components of the field. Small organisms, such as, *tribolium pupae* will be introduced into known parts of the field and the bioeffects (wing deformation in the imagio) determined. This series of experiments should provide some of the first information available on specific bioeffects of E- and H-fields at microwave frequencies. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0007 BEHAVIORAL CHARACTERISTICS OF MONKEYS AND RATS IRRADIATED WITH MICROWAVES. Delorge, J. O.; Beischer, D. E. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

The effects of low power density microwave radiation on monkeys and rats will be investigated by measuring their ongoing operant behavior. Rhesus monkeys, squirrel monkeys, and rats trained on various operant tasks will be exposed for prolonged durations to microwave radiation at power levels of 8-16 mW/cm^2, pulsed at selected frequencies. The animals, while working, will be exposed to vertically or horizontally polarized radiation at 1.7 and 6 GHz to demonstrate differential effects of polarization and frequency. The exposures will occur in essentially non-reflective restraint devices. In addition the animals, chosen for size differences, will perform similar tasks and provide information for comparative study of animal size and microwave parameters utilizing behavior as the dependent variable. This new work unit continues previously performed research. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0008 COMPARISON OF THEORETICAL AND EXPERIMENTAL ABSORPTION OF RADIOFREQUENCY. Durney, C. H.; Johnson, C. C. (Univ. Utah, Sch. Engineering, 1400 East 2nd St., Salt Lake City, UT 84112).

Recent data indicate that the biological hazard of nonionizing electromagnetic radiation is frequency dependent, and body shape, size, and orientation are important variables affecting power deposition and subsequent hazard. The Air Force is advocating a frequency related safety standard approach with the objective of extending theoretical radiofrequency power absorption calculations and to perform experimental measurements necessary for assessing realistic personnel exposure criteria in the 10 kHz to 100 MHz frequency range. Assessment techniques will account for size and orientation effects, to extrapolate from animal to human radiofrequency exposure situations. A set of prolate spheroid models will be constructed to represent the rhesus primate and human. Theoretical calculations will be made to determine the amount of power absorbed for exposures between 10 kHz and 100 MHz. Power absorption measurements will be performed from 10-30 MHz and the results compared with theory. Rhesus primates will be exposed in the same geometry as the phantoms to evaluate anisotropic effects. The resulting data will be used to establish appropriate personnel exposure guidelines for a broader frequency range

than can be measured with available experimental apparatus. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0009 IONIZING AND NON-IONIZING RADIATION BIOLOGY. Appleby, A. (Rutgers State Univ., Agricultural Experiment Station, Old Queens Building, New Brunswick, NJ 08903).

The investigators will evaluate the effect of chronic low level microwave exposures on the mammalian anterior lens as they relate to cataract formation at various age levels. Fundamental data will be obtained relevant to the understanding of the chemical and biological processes involved in the interaction of radiation with organisms. The results will be used to develop practical means to inhibit, neutralize, or reverse the biological damage caused by radiation. The mitotic index of chosen mammalian species of different age groups will be measured after various exposure periods, using a tritiated thymidine-autoradiographic technique, followed by observing cataract producing doses. The relative radiation sensitivity of experimental animals (e.g., rats) with or without treatment by radiated gas will be determined by standard procedures. (7/75-6/76)

Supporting Agency:New Jersey State Govt.

0010 IMPACT OF RF BIOEFFECTS ON AF OPERATIONS. Mitchell, J. C.; Hardy, K. A. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Specific Air Force systems radiofrequency emission and bioeffects studies will be conducted, and a state-of-technology data base will be maintained to support environmental impact positions and operational radiofrequency safety criteria for future and ongoing systems such as AN/FPS-85, AWACS, 487L, 414L, PAVE-PAWS, and SEEK-SAIL. Radiofrequency radiation effects data applicable to Air Force radiofrequency safety criteria and systems' operations will be compiled as background information. Systems' studies will be undertaken in accordance with mission direction. The radiofrequency biomedical data base generated under this effort will be used to support the Air Force petition for a change in OSHA standards, Title 29, CFR 1910.97 and in the revision of AFM 161-7. Initial state-of-the-art data will be obtained through a multi-agency contract with the Franklin Institute to provide a quarterly *Digest of Biological Effects of Microwave and Radiofrequency Radiation*. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0011 NAVY ENVIRONMENT: EFFECTS ON BIOLOGICAL SYSTEMS DUE TO MICROWAVE IRRADIATION. Durney, C. H.; Lords, J. L. (Univ. Utah, Sch. Engineering, 1400 East 2nd St., Salt Lake City, UT 84112).

Recent increases in the use of microwave emitting devices have caused growing concern about the health hazards resulting from exposure of personnel to microwave radiation. Though there is general agreement on the hazards resulting from tissue heating by high-level microwave irradiation, little is known about possible damage produced by exposure to low-power microwave radiation. This research is investigating the response of isolated turtle hearts to pulsed irradiation and to different frequencies. Hearts from freshly killed turtles are placed in Ringers solution and a record of physical and electrical activity is taken until stabilization occurs. Microwave power is then delivered to the heart, and the activities of the heart recorded. Chemical stimulants and depressants are added to determine which of the two parts of the autonomic nervous system is most affected by the microwave field. The microwave field parameters are varied and mammalian (rat) hearts also are being studied. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0012 BIOLOGICAL EFFECTS OF MICROWAVES. Baranski, S. (Coord. Comm. Polish American Collab., Warsaw, Poland).

The objective of this monograph is to reduce the effects of microwave irradiation and improve current treatment methods by disseminating new knowledge and technological capability. The monograph, intended for international use in research or medical practice, will review the biological effects of microwave irradiation. The use of microwave generators in industry, radio-navigation, radio-communication, radio-location, and in research will be reviewed, and the possible hazards for personnel employed within the compass of irradiation will be identified. The physical characteristics of microwaves, the biological effects of microwave exposure, and methods aimed at preventing the health hazards arising from continued exposure to microwave irradiation will be identified. The monograph will consist of approximately 350 pages including supporting tabulations and photographs. (7/75-6/76)

Supporting Agency:HEW, PHS, NIH, Fogarty Intl Ctr.

0013 NAVY ENVIRONMENT: INVESTIGATION OF THE BIOLOGICAL EFFECTS OF PULSED ELECTROMAGNETIC FIELDS GENERATED BY NAVAL OPERATIONS. Cleary, S. F. (Virginia Commonwealth Univ., Sch. Medicine, 901 W. Franklin St., Richmon, VA 23219).

High frequency, high intensity electromagnetic pulse (EMP) fields can be produced by certain naval operations. Evidence tends to point toward reversible effects in some biological systems. This research is an attempt to determine whether the instantaneous field strengths and pulse characteristics of EMP are capable of producing biological alterations of interest to man. This will be a two-part study. The first will be a study of the effects of EMP fields on serum proteins, blood chemistry, and drug-induced (pentobarbital) sleeping time in the dutch rabbit. Comparisons will be made to recent related study

findings. The second phase of this work will examine the EMP fields on an artificial biomembrane of known resistance, membrane potential, and dielectric breakdown potential. These membrane properties will then be investigated as a function of the amplitude and pulse repetition rate of an applied EMP field. All exposures will be made using the EMP simulator at the naval weapons laboratory, Dahlgren, Virginia. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0014 NAVY ENVIRONMENT: MUTAGENIC EFFECTS DUE TO MICROWAVE RADIATION GENERATED BY NAVAL OPERATIONS. Varma, M. M.; Joshi, S. R. (Howard Univ., Sch. Engineering, 2400 6th St. N.W., Washington, DC 20001).

The use of microwave generators in communications, navigations, industry and the military has increased tremendously in recent years. The possibility exists that naval personnel may be exposed to these radiations. This research will evaluate the mutagenicity as a function of frequency, exposure time, and power level of microwaves when used to expose testes of mice. Mice testes will be exposed to microwaves at the Walter Reed Army Medical Center. After each exposure the males will be mated to three unexposed virgen females for five days. The females will be replaced weekly for eight consecutive weeks. Mated females, as evidenced by the presence of a vaginal plug, will be dissected on day 13 of the pregnancy and the total number of implants, viable implants, and early and late fetal deaths will be recorded. The results will be compared with concurrent control groups. Adverse genetic effects will be studied by observation of the F1, F2 and F3 progeny of exposed male mice. The experiments have proceeded in an orderly fashion since they were begun. There is some indication that the percentage of early deaths resulting from matings is related to the time of mating following exposure of the mouse testes. Results are still inconclusive pending further tests now in progress. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0015 NAVY ENVIRONMENT: QUANTITATION OF MICROWAVE RADIATION EFFECTS ON THE HEAD AND EYES OF RABBITS, PRIMATES AND MAN. Kramer, P. O.; Emery, A. (Univ. Washington, Sch. Medicine, C304 Health Sciences Building, Seattle, WA 98105).

Exposure to microwave radiation can cause the production of opacity and damage in the eye. The exact conditions under which the effect occurs are yet to be established. Consequently, there is a great deal of controversy concerning the safe level of human exposure to microwave radiation. The increased use of high power microwave equipment by the Navy and other armed services, as well as by the general population, demands well-planned and expertly executed theoretical and experimental investigations. Using well established and quantified exposures, the cataractogenic threshold for the eyes of the rhesus monkey will be established for 2450 MHz. A computer model of the power absorption in the eye of the monkey, together with the model of the rabbit eye should allow for some extrapolation to humans. Rabbit lenses will be exposed to threshold and sub-threshold levels of microwaves and sections will then be examined by electronmicroscopy for ultrastructural changes. A number of rabbits will be exposed to chronic, sub-threshold levels. Studies of the disturbances in blood coagulation mechanism will be monitored together with the eye examinations. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0016 NAVY ENVIRONMENT: NEUROPHYSIOLOGICAL AND BEHAVIORAL EFFECTS DUE TO MICROWAVE IRRADIATION. Guy, A. W.; Lovely, R. H. (Univ. Washington, Sch. Medicine, C304 Health Sciences Building, Seattle, WA 98105).

An outstanding problem in the interaction of microwave energy with biological systems is one of determining at what level the interaction constitutes a hazard. In order to provide a better understanding of the hazards associated with microwave irradiation and a scientific basis for safety standards, it is proposed in this study to quantify the biological effects of continuous wave and pulsed microwaves, as well as their frequency and intensity dependence through controlled exposure of test animals. Current emphasis in this research on the effects of acute and chronic exposure to microwave radiation in laboratory animals is placed on the quantification of behavioral change effects and on physiological mechanisms, such as, the endocrine stress response. Behavioral studies are carried out by using operant and classical conditioning techniques. Monitoring of pituitary-adrenal axis activity will determine the influence of microwave radiation on normally functioning hormonal systems. Additional work is concerned with a theoretical investigation of energy distribution inside the animal bodies. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0017 BIOLOGICAL EFFECTS OF AF RF TRANSMITTER FIELDS. Frazer, J. W.; Merritt, J. H. (U.S. Air Force, Sch Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Firm foundations for electromagnetic safety standards for Defense Department personnel and the general population affected by Department of Defense radiators, depend on: (1) precise knowledge of the magnitude of the radiofrequency insult, as in any environmental consideration, (2) the relationship between insults and responses of experimental animals to those of man, (3) the bases on which the insult, in this case internal distribution of electromagnetic fields, acts, and (4) the magnitude of insult levels no longer producing a measurable response. This effort will investigate the biological consequences of Air Force aircrew exposures to unique radiofrequency radiation environments and to extrapolate the empirical findings to adjust personnel exposure criteria. Responses of experimental animals to field modulations reportedly

at frequencies of brain theta rhythms have been reported. The present hypothesis of high field Kerr effects and low field thermal distribution as major factors in inducing responses to electromagnetic radiation fields are at variance with assumed processes producing such effects. Field modulation effects, including pulsed fields, on a variety of central nervous system ionic and chemical distributions will be examined. Lymphocyte responses will be examined as a function of field amplitude in intact animals, while culture responses are examined in another study. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0018 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE IRRADIATION. Justesen, D. R.; Sheridan, C. L.; Levinson, D. M. (U.S. Veterans Admin. Hosp., 4801 Linwood Blvd., Kansas City, MO 64128).

Three years after fetal irradiation by 2450 MHz microwave energy, the last survivors among a group of CWF mice have now died. The rats were irradiated once daily on the 11th-14th days of gestation with a 36 J/g energy dose administered at the rate of 30 mW/g for 1200 seconds. The rats were exposed in a multi-mode cavity at 20°C and with a high turnover of air (approximately 3 M^3/min), at 40-60 percent relative humidity. Complex modulation was used: 60 Hz sinusoid half-waves superimposed upon 12 Hz pulses induced by mode-stirring. Sham-irradiated control mice reached the 50 percent mortality level near the 22nd month, post-partum; radiated mice, near the 31st month. In the same study, mice that had been innoculated with an homogenate of reticular cell sarcoma developed tumors at a slower rate in radiated than in sham-irradiated groups. The finding of enhanced longevity of mice (p much less than .01) following intense fetal microwave irradiation confirms that found (but apparently not recognized) earlier by Prausnitz & Susskind (IRE Trans. on Biomed. Elec., BME-9, 104-108). In another study, teratology, survival, and maze learning by mice of the C3H/HeJ strain were observed after a single, fetally administered dose (approximately 23 J/g) of energy in the same cavity. Dosing of dams on the 11th, 12th, 13th, or 14th day of gestation had no reliable effects as a function of radiation per se. However, high rates of fetal mortality resulting from treatment of dams with a single, 5 mg dose of cortisone as an acetate were reliably reduced by the 23 J/g dose of radiation. (7/75-6/76)

Supporting Agency:U.S. Veterans Adm.

0019 PERSONNEL TECHNOLOGY: THE EFFECTS OF IONIZING AIR AND RADIO ENERGY UPON THE PERFORMANCE OF NAVAL PERSONNEL. Frey, A. H. (Randomline Inc., Old York & Moreland Rd., Willow Grove, PA 19090).

Navy personnel are exposed, in many relatively closed spaces, to varying levels of electromagnetic radiation and/or ionized air which could affect individual performance. This work unit is concerened with the effects of exposure to radiofrequency energy and ionized air on neural activity and behavior. The effects of prolonged exposure to low power, modulated VHF energy on the physiology and behavior of mammals are being studied. The experiments employ a fluorescent dye technique as an indicator of brain barrier permeability and a behavioral measure which gives quantifiable data to relate to the physiological data. A comparison of the effects of natural light spectrum exposure and cool white spectrum exposure on physiology and emotionality also is underway. The work will determine whether such exposures affect physical performance and neuro-endocrine function. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0020 NAVY ENVIRONMENT: X-RAY AND MICROWAVE RADIATION INTERACTION WITH MUSCLE CELLS; APPLICATION TO PROTECTION AND TREATMENT. Portela, A.; Perez, J. C. (Consejo Nac. de Inv. Cien. Tec, Junin 956, Buenos Aires, Argentina).

This research seeks to identify and characterize in cellular and subcellular structures the critical membrane systems, organelles, and biochemical mechanisms that are affected by the absorption of ionizing (X-rays) and nonionizing (microwaves) radiation likely to exist in the environment of naval personnel. Efforts will be made to develop specific agents to prevent or counteract side-effects of these radiations. This research will concentrate primarily on microwave irradiation. The area and nature of damage due to microwave fields at the cellular and subcellular level is being investigated *in vivo* and *in vitro*, using skeletal muscles of frogs and rats. Several parameters of cells and cell membranes such as water content, ion transport, conductance, protein-phospholipid structure and resistance and capacitance, will be analyzed for microwave induced changes. Electromagnetic emission from active nerve and muscle fibers will be spectrally analyzed to determine if this technique is able to detect changes due to nonionizing and ionizing radiation. (7/75-7/76)

Supporting Agency:U.S. Dep. Def., Navy.

0021 MECHANISMS OF NEUROENDOCRINE RESPONSE TO ELECTROMAGNETIC RADIANT ENERGY. Michaelson, S. M. (Univ. Rochester, Sch. Medicine & Dentistry, 601 Elmwood Ave., Rochester, NY 14642).

Neuroendocrine function provides a sensitive indicator of the body response to environmental insults. As representative of the neuroendocrine systems, the hypothalamic-hypophysial-end organ axis (HHEO) has been chosen for study. Because of the importance of this hierarchical system to the body's economy, perturbation at any link in the chain could have profound pathophysiologic consequences. Studies are being performed in the rat and dog to relate the sequential changes in hypothalamic and pituitary function to alterations in body metabolism or homeokinetic perturbations as a result of exposure to various regimens of X-rays, microwaves, or combinations of these two electromagnetic energies. Various periods in the lifespan of the rat from neonates to old age are being studied. Radioim-

munoassay techniques are utilized to measure fluctuations in pituitary hormones; to study homeostasis, impairment of physiologic capacity, and structural and functional integrity of the neuroendocrine system; to assess alteration in circadian rhythms, maturation, and pathophysiologic sequelae as a consequence of exposure to electromagnetic radiant energies. The influence of microwaves alone and together with X-rays in the therapy of cancer is also under investigation. Studies on head and neck X-irradiation of rats indicate that the processes leading to the appearance of pituitary and thyroid neoplasms are hormone dependent. In the head X-irradiated dog, thyrometabolic consequences are compatable with secondary hypothyroidism due to hypopituitarism and/or a hypothalamic lesion. Assay of adrenalcortical function in rats exposed to microwaves reveals a definite correlation between corticosterone and colonic temperature. This suggests nonspecific stress at certain power density/time relationships for microwave irradiation. (7/75-6/76)

Supporting Agency: ERDA

0022 VARIABLE FREQUENCY MICROWAVE EXPOSURE SYSTEM. McRee, D. I.; Walsh, P. J.; Mathews, P. (U.S. Dept. Health, Education & Welfare, Public Health Service, Natl. Inst. Health, Durham, NC 27709).

The purpose of this study is to develop a microwave exposure system that can provide a plane-wave type field and a variable frequency capability of 1-10 GHz. The system has been assembled and calibrated. The system generates a 90% uniform field over a 10 cm diameter circle with a power density capability range of 0-20 mW/cm^2. Small biological specimens can be exposed to variable frequencies in either a continuous wave or modulated wave mode. (7/75-7/76)

Supporting Agency:HEW, PHS, NIH.

0023 REGIONAL CNS UPTAKE OF AMINO ACIDS. Perez, V. J. (Texas Technological Univ., Sch. of Arts & Sciences, P.O. Box 4340, Lubbock, TX 79409).

The major objectives of this research are (1) to measure in infant and adult mice the smallest amount of glutamate (Glu) that accumulates in the arcuate nucleus of the hypothalamus (ARH) to produce neuronal necrosis, (2) to determine if there is a time in gestation when the brains of fetal mice are unaffected by Glu, (3) to ascertain why GABA, glutamine and alanine are not toxic in the central nervous system, (4) to determine if other toxic amino acids accumulate in the ARH as does Glu, and (5) to compare the effects on consummatory behavior of radiofrequency lesions and those produced by excitatory amino acids. Results will contribute to the understanding of placental barriers to amino acids and will provide a better understanding of central nervous system regional blood-brain-barriers to specific amino acids and how these change with age. Comparisons of rates of central nervous system uptake and maximal levels reached and time course of return to control levels will be made between Glu and Asp, both of which are neurotoxins. Data will be obtained to determine if nontoxic amino acids are accumulated in the ARH as is neurotoxic Glu. Results obtained from these studies of experimentally induced lesions will enable the evaluation of the importance of an intact neuronal and/or neuroglial system in maintaining function "regulated by" lesioned areas. Results from these experiments go beyond those in which tissue slices or whole brain are used because quantitative histochemical measurements will be made in histologically homogeneous brain areas. Long term goals of this research are to measure the metabolism of neurotoxic amino acids in the ARH and liver, to investigate how patterns of metabolism vary with age, and to study behavioral abnormalities, which may be produced by neurotoxic amino acids and localizing subcortical neuronal destruction. (9/75-8/76)

Supporting Agency:HEW, PHS, NIH.

0024 VESTIBULO-COCHLEAR EFFECTS OF UHF-MICROWAVE RADIATION. Lebovitz, R. M.; Seaman, R. (Univ. Texas, Sch. Medicine, 5323 Harry Hines Blvd., Dallas, TX 75230).

This research concerns the experimental examination of the neural activity in the vestibular system of animals subjected to acute, cranial microwave radiation. This work will proceed initially on mongrel cats and progress to monkeys as techniques are refined. With the animal immobilized in a stereotaxic frame, we apply microwave radiation to the cranium at an incident frequency of 918 MHz, using power densities in the range of 5-80 mW/cm^2. The relevant data include gross field and single cell electrical activity in the vestibular nerve and associated nuclei. Interspike intervals are analyzed by computer for average rate and interval statistics, and correlated with the microwave radiation. As a control, known but weak cranial acceleration is applied before and during microwave radiation exposure to classify the unit and field response pattern. Other controls include vestibular nerve section, intracranial temperature monitoring, and histological verification of electrode sites. Particular attention is paid to the suppression of microwave radiation induced field artifacts in electrodes and to the calibration of absorbed energy. A secondary aim of this work will be to examine similarly the effects of microwave radiation on unit activity in the auditory pathway. (5/76-4/77)

Supporting Agency:HEW, PHS, FDA.

0025 ULTRASTRUCTURAL STUDIES OF MICROWAVE CATARACTOGENESIS. Simon, D. R.; McKee, A. E. (U.S. Navy, Experimental Pathology Dept., Bethesda, MD 20014).

Microwave radiation (electromagnetic radiation, EMR) has been shown to be cataractogenic. Although some reports suggest that microwave cataracts are a consequence of elevated intraocular temperature associated with microwave radiation, the mechanism(s) of microwave cataractogenesis, earliest structural changes in the lens, and exposure thresholds remain controversial. Exposure of both military and civilian personnel to

microwave radiation (radar, microwave ovens, etc.) may, indeed, constitute a genuine health hazard. The objective of this research is to investigate the earliest ultrastructural changes in mammalian lenses following exposure to electromagnetic radiation, with special emphasis on defining the thermal effects. Microwave cataractogenesis will be studied using scanning and transmission electron microscopy and light microscopy. New Zealand red rabbits and owl monkeys will be used as experimental animals. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0026 GENETIC AND CELLULAR EFFECT OF MICROWAVE RADIATION. Dutta, S. K.; Nelson, W. H.; Blackman, C.; Brusick, D. (Howard Univ., Sch. Liberal Arts, 2400 6th St. N.W., Washington, DC 20001).

The proposed research will utilize a fast and highly sensitive series of genetic tests and simple tests to study cell morphological changes in order to evaluate the effects of low intensity microwave radiation. Since the nonthermal (< 1 mW/cm^2) effects of microwaves are difficult to distinguish from the thermal effects in large whole animal systems, the distinction will be studied using repair-deficient his-mutants of *Salmonella typhimurium* and D-4 strain of *Saccharomyces cerevisiae*. Two component heterokaryons and excision repair-deficient mutants of *Neurospora crassa* will be used to investigate chronic and delayed effects of continuous and pulsed microwaves in the environment. Work will then be extended to study alteration, if any, of repair process by microwave radiations using human fibroblast cultures. (7/75-6/76)

Supporting Agency:EPA

0027 EFFECTS OF CHRONIC EXPOSURE TO HIGH PEAK POWER PULSED ELECTROMAGNETIC RADIATION ON ANIMALS. Ogrady, T. C.; Hosszu, J. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

The objective of this study is to evaluate the long term effects of exposure to high peak power (HPP) pulsed electromagnetic radiation to develop information useful in safety factor analysis. It is intended to find some areas of interaction between the HPP radiation and the functioning biological systems in animals and to investigate these areas in further detail. The experimental approach involves the chronic (up to 10 months) exposure of laboratory animals, usually rodents, to HPP electromagnetic radiation. Three groups of approximately 100 animals each will be used as follows. Two groups of 100 animals each (70 experimental, 30 controls) will be exposed from day of birth to full maturity. At two months of age, 7 experimental and 3 controls will be sacrificed at 20 day intervals and analyzed. The third group of 100 (70 experimental, 30 controls) will be exposed from birth and then sacrificed from 1 day after birth to 2 months at 2 day intervals for the first 10 days and twice weekly intervals for the remaining time. After sacrifice, a variety of parameters will be investigated in each case including: clinical hematologies (hematocrit, platelet count, WBC, differential count), serum proteins, gross anatomy and activity of a series of glycolytic and gluconeogenic enzymes (phosphoglycerate kinase, phosphofructokinase, pyruvate kinase, and hexokinase) from liver, skeletal muscle and heart. This approach should identify specific areas for further, more detailed studies of *in vivo* and *in vitro* systems. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0028 LABORATORY AND FIELD EVALUATIONS OF HEAT ENERGY TO CONTROL STORED-PRODUCT INSECTS. Kirkpatrick, R. L. (U.S. Dept. Agriculture, Stored Products Insects Research & Development Lab., 3401 Edwin Ave., Savannah, GA 31405).

The objective of this project is to develop rapid, simple, and practical techniques in the laboratory and adapt these methods for field evaluations using temperature, including infrared and microwave radiation, to control stored-product insects infesting grain or other stored commodities. Research data obtained from these laboratory and field tests will be used to develop a practical and inexpensive commercial unit to control stored-product insects. The laboratory tests will determine the repellancy, attractancy, effect on life history, behavioral responses, and dosage-mortality relationship of stored-product insects exposed to infrared, microwave radiation and other types of heat energy. (7/75-6/76)

Supporting Agency:U.S. Dep. Agric., Agric. Res. Serv., Georgia/South Carolina Area.

0029 THE EFFECTS OF MICROWAVE RADIATION ON THE CENTRAL NERVOUS SYSTEM. Albert, E. N. (George Washington Univ., Sch. Medicine, 1331 H St. N.W., Washington, DC 20037).

This research will investigate the existance of morphological alterations in animals exposed to microwave irradiation. Chinese hamsters will be irradiated with microwaves at 12.5 cm and power levels of 10, 25, and 50 mW/cm^2. Brain nuclei will be examined for radiation-induced changes using both light and electron microscopy. Special emphasis will be placed on the mitochondria, nucleolus, rough endoplasmic reticulum, golgi apparatus, and lysosomes. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0030 INVESTIGATION OF BIOMOLECULAR FUNCTIONS BY MICROWAVE RADIATION. Eisenbud, M., Rabinowitz, J. R. (New York Univ., Sch. Medicine, 550 First Ave., New York, NY 10016).

The objective of this research is to describe the mechanisms by which the absorption of microwave energy can interfere with the function of the absorbing biological molecule. An attempt will be made to demonstrate these mechanisms in biological systems and identify the specific biomolecules involved.

Tranquilized rabbits will be irradiated at 2450 MHz to determine the cause of the decrease in ascorbic acid concentration of the lens. Irradiated and control lenses will be cultured in a medium containing C^{14} ascorbic acid; C^{14} activity of the lenses will then be determined after removal from the medium. If it is transport that is affected, and the element changed is in the transport system of the lens, then an attempt will be made to determine whether ascorbic acid transport is stereo-specific in the lens. In addition, the research is aimed at determining whether microwave irradiation increases the concentration of acetylcholamine when an animal is irradiated at 2450 MHz using a power density of 40 mW/cm^2, and whether the hydrolysis of acetylcholamine by acetylcholine esterase is affected by irradiation. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0031 NAVY ENVIRONMENT: EFFECTS OF MICROWAVE RADIATION AS FROM NAVY RADAR ON EMBRYONIC BRAIN TISSUE. Rioch, D. (Inst. Behavioral Research, 2426 Linden Lane, Silver Spring, MD 20910).

The objective of this research is to determine whether there is a critical period(s) in the circadian rhythm of the rat fetus during which microwave fields are effective in increasing the fetal growth, particularly the growth of the cerebral hemispheres. Pregnant Holtzman (albino) rats will be exposed to 1700 MHz, 10 mW/cm^2 microwaves from 1700-1800 hours on the 6th-9th and 12th-16th days of gestation. Additional rats will be similarly exposed overnight for 12-14 hours at 5 mW/cm^2. On the 20th day of gestation, the rats will be sacrificed, fetuses weighed and brains removed and fixed in Bouin's solution. The gross form and size of the brains will be studied under a dissection microscope. The brains will then be dehydrated and imbedded in paraffin for histological evaluation. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0032 EFFECTS OF HIGH POWER PULSED AND LOW LEVEL MICROWAVE RADIATION ON OPERANT BEHAVIOR IN RATS. Diachenko, J. A.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

This study will evaluate the effects of nonionizing electromagnetic radiation on animal behavior. Analogous animal behavior (rats and rabbits) will be studied over a range of electromagnetic combinations of frequency, low level power and exposure durations. Results will contribute to: (1) better definition of electromagnetic radiation exposure safety margins, (2) understanding perception of electromagnetic energy, (3) differentiation between chronic and acute effects relative to time frame of behavioral change onset, course, and recovery. Standard operant conditioning techniques will be used wherein quantified response rates such as bar pressing are rewarded with food to establish a predictable baseline performance in lower animals. Subjects will then be systematically exposed for long durations (i.e., 2 hours daily for 2 months or more) to combinations of high power pulsed fields, pulse modulated and continuous wave fields over a wide range of frequencies, and power levels. Also, as a collaborative effort, subjects studied for specific neurophysiological change by other researchers will be behaviorally tested to see how neurological changes might be reflected in behavioral correlates. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0033 ALTERATIONS IN THE SLEEP PROCESS OF THE RABBIT AS A FUNCTION OF CHRONIC LOW INTENSITY ELECTROMAGNETIC RADIATION EXPOSURE. Manthei, R. C.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

Data have shown brain electrical activity associated with sleep states to be biologically constant for any given species. Furthermore, nonionizing radiation exposure has been shown to alter brain electrical activity. The sleep process is characterized by cyclic fluctuations between alertness (W), slow wave (SW), and paradoxical (REM) stages. Rapid eye movement (REM) is a very active state metabolically. REM is functionally defined as that period of sleep in which cortical activity paradoxically reveals low voltage, fast activity characteristic of the awake phase, concurrent with rapid eye movement, and atonus of neck muscle. This study is designed to test the hypothesis that prolonged exposure of an organism to electromagnetic radiation will decrease the frequency and duration of REM stage sleep. These data, if tenable, will guide the author toward synergistic bodies of biochemical, anatomical, and behavioral data relative to the sleep process. Sleep is viewed as a potential index of central nervous system adaptation to prolonged electromagnetic radiation exposure while being associated with broad theoretical, yet practical implication. Brain electrical activities of rabbits surgically implanted with plastic guide tubes will be continuously monitored for a period of up to sixty days following daily exposures of microwave and pulsed high energy (HEP) electromagnetic radiation. The scope of this project depends on the inexpensive test of the REM sleep hypothesis. Data should be available within three months from the onset of the irradiation and should be considered conclusive evidence for, or against, sleep modification. Positive results will require consideration of biochemical, anatomical and behavioral correlates to the sleep process as related to electromagnetic radiation insult. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0034 BIOPHYSICS OF ELECTROMAGNETIC FIELD INTERACTIONS. Frazer, J. W.; Sexauer, S. W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Present electromagnetic radiation safety standards based on total power absorption and resulting thermal load are being challenged on the basis that pulsed fields may be more harmful to man than equivalent

continuous wave fields. The objective of this effort is to investigate the relative effect of pulsed and continuous wave fields on a large variety of tissue components. Several sizes of experimental animals will be examined for different field distributions radiometrically. Several types of tissue, both within animals and as slices in a special spectrometer cell, will be examined for polarization and fluorescence changes of compounds whose Kerr constants have been determined in free solution. Polarization, dual and triple wavelength spectrometry and special fluorescence polarization measurements are to be utilized. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0035 EFFECTS OF HIGH PEAK POWER PULSED ELECTROMAGNETIC RADIATION ON CELLULAR KINETICS. Ogrady, T. C.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

The objective of this study is to evaluate the long term exposure effects of high peak power (HPP) electromagnetic radiation on cellular systems to develop information useful to be used in safety factor analysis. The main value in studying such simple systems as bacteria and root meristematic tissue lied in the use of these systems as models of more complex systems. Thus, the growth of bacteria and the division cycle of root tip cells reflect processes occurring in higher organisms. Furthermore, the rapidity of these processes allow many experimental replicates with a variety of experimental parameters being investigated (e.g., power levels, frequencies). The experimental approach in these experiments is divided into two areas—bacterial growth kinetics and root tip cell cycle timing studies. The bacterial studies involve exposing populations of common bacteria (*Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Serratia marcescens*) during their entire growth cycle to fields of approximately 100 kV/m, 25 MHz frequency. At various time intervals, aliquots are withdrawn and counted in a coulter counter. Comparison can then be made between control and experimental groups' growth kinetics. The root tips (of *Vicia fava*) are exposed for 12 hours (100 kV/m, 25 MHz) prior to a 1 hour pulse label with ^{3}H-thymidine. The labeled root tips are transferred to non-radioactive media and then harvested at hourly intervals, stained with acid shiff (feulgen) stain to reveal chromosomes, and autoradiographed. After exposure and development, the slides are observed microscopically to determine the presence of labeled chromosomes. The numbers of labeled chromosomes versus time after pulse labeling allows cell cycle timing to be determined. This parameter can then be compared between control and experimental groups. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0036 NAVY ENVIRONMENT: WORK SESSION—THE ROLE IN BRAIN FUNCTION OF EXTERNAL ELECTROMAGNETIC FIELDS AND ELECTROTONIC INTERACTIONS BETWEEN NEURONS. Worden, F. W. (Massachusetts Inst. Technology, Graduate Sch., Cambridge, MA 02139).

It is generally acknowledged that the central nervous system is critically sensitive to electromagnetic fields. In order to better understand the interactions which occur, this work session will attempt to increase the knowledge of the basic electrophysiological processes within the human brain. The neurosciences research program will plan a work session, with suitable input from ONR, which will assemble approximately 25-30 of the world's leading scientists in neurophysiology, neuroanatomy, biophysics and bioengineering. Following the 2-day work session, the proceedings will be published in a special issue of the NRP bulletin. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0037 THE EFFECTS OF EXTREMELY LOW FREQUENCY (ELF) RADIATION ON MAN. Deischer, D. E.; Grissett, J. D. (U.S. Navy, Aerospace Medical Res. Lab., Pensacola, FL 32512).

Navy operational interest in electromagnetic radiation effects on man includes the possible effects of the extremely low frequency region of the spectrum. A series of carefully selected physiological and psychological tests is being used to determine the effects of low intensity fields below 100 Hz. Well-controlled laboratory exposure of animals and human volunteers should furnish needed data. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0038 ALTERED CSF CONSTITUENTS AS A FUNCTION OF CHRONIC LOW INTENSITY ELECTROMAGNETIC RADIATION EXPOSURE IN RABBITS. Manthei, R. C.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

The nerve membrane surface contains macromolecules whose functional group, sialic acid (NANA), allows for rapid conformational change and reversible binding of calcium ion. Two such classes of macromolecules, gangliosides and glycoproteins, can be judged as to complexity and binding capability by means of sialic acid content. It is hypothesized that electromagnetic radiation exposure could alter both sialic acid and calcium content in whole brain extracts and cerebrospinal fluid. Since cerebrospinal fluid is intimately associated with extracellular fluid surrounding neuron populations, it is reasonable to suggest that membrane-bound substances, including calcium ion, might appear in cerebrospinal fluid following electromagnetic radiation exposure. The author suggests that such membrane alterations as a function of electromagnetic radiation insult could affect the quantal presynaptic release of neurotransmitter substances. This mechanism is viewed as vital to central nervous system function. Techniques required for analysis of sialic acid and calcium will be perfected using whole brain extracts of adult male mice. Such techniques will then be applied to rabbit brain tissue, cerebrospinal fluid, and serum samples. Rabbits will be surgically implanted with cannulae suitable for cerebrospinal fluid and blood extraction. The implant will be designed such that no metal elements are associated with the animal during exposure. Values obtained

from cerebrospinal fluid and blood will be obtained on a daily basis following daily exposure to chronic low intensity microwave and high energy pulsed electromagnetic radiation. Following a period of time specified by irradiation protocol, the animals will be sacrificed, and whole brain analysis will be performed. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0039 MICROWAVE THAWING OF FROZEN TISSUE. Lehr, H. B.; Holst, H. I.; Ketterer, F. (Univ. Pennsylvania, Sch. Medicine, 36th & Hamilton Walk, Philadelphia, PA 19104).

The use of microwaves to thaw solid organs, viably preserved in the frozen state is intriguing and promising. The objectives of these experiments are threefold: (1) to measure the unknown electrical properties of frozen tissue, (2) to calculate the heating potential distributions of solid organs and to develop equipment to apply microwaves evenly to these organs, and (3) to prove that properly prepared frozen solid organs are viable in mammalians. These objectives are to be accomplished by direct measurements of the electrical properties of ice, physiological saline with cryoprotectants, gelatin molds, and frozen mince mammalian tissue. The thawing equipment will be a meld of commercially available microwave ovens in different frequency ranges with rabbit and canine kidneys comprising the mammalian test organs. (4/76-3/77)

Supporting Agency:HEW, PHS, NIH

0040 MEDICAL SURVEILLANCE OF PERSONNEL OCCUPATIONALLY EXPOSED TO ELECTROMAGNETIC RADIATION. Benedum, J. L.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

This task is to evaluate the effects of exposure to nonionizing electromagnetic radiation (EMR) on occupationally exposed personnel. The aim is to develop health and safety information for use with personnel exposed to various EMR systems. Particular emphasis is placed on advanced systems such as high power pulse (HPP) generators. An additional objective is to provide input into hardware development at an early state of design to produce better intrinsic safety features. A group of approximately 100 NSWC/DL personnel is examined on an annual basis. The group includes: microwave and radiofrequency exposed personnel, personnel exposed to high peak power pulse (HPP) transmitters, and a control population with no occupational exposure to EMR. The examination includes a hematocrit, white blood count, differential count, a urinalysis, a modified SMA-12 serum chemistry analysis, an electrocardiogram, and a screening electroencephalogram. Records of ophthalmologic examinations, performed on contract by a private ophthalmologist, are reviewed. The merger of NOL and NWL to form NSWC has brought an additional occupational group into the study—personnel exposed to the empress electromagnetic pulse (EMP) simulator. These examinations are performed at NSWC/WOL with results forwarded to this laboratory for analysis. Data obtained are statistically analyzed on the CDC-6600 computer both between groups and longitudinally within groups. Close contact is maintained with the subject populations throughout the year so that situational examinations may be done as indicated. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0041 VISUAL SYSTEM DISEASES IN AIRCREWMEN. Tredici, T. J.; Shacklett, D. E. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

This study attempts to determine the incidence and significance of diseases of the visual system in aircrewmen from the standpoint of retention without compromising flying safety. Investigators are trying to develop the means to prevent or correct such disorders and develop techniques for early diagnosis or prediction of development of such disorders. Aircrewmen with ophthalmologic problems receive a comprehensive aeromedical evaluation and a battery of function testing, including manifest and cycloplegic refractions, motility tests, tonometry, tonography, fundus photography. Response to aerospace environmental factors (e.g., acceleration, altitude and electromagnetic radiation) is studied in special cases. Longitudinal basic studies will assess the significance of disease in relation to flying operations and the validity of current aeromedical standards. Fluorescein fundus photography, electro-retinography, electro-oculography, static perimetry, and biomicroscopy will be utilized to study the effect of disease and stress on aircrewmen. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0042 CARDIAC OUTPUT MEASUREMENT BY MEANS OF RF ATTENUATION MEASUREMENT. Frazer, J. W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Cardiac output determinations are necessary to acquire physiological data on which to base safe exposure criteria for Air Force operational environments. Present cardiac output measurements in high acceleration or radiation environments depend on vascular intervention with subsequent laboratory analysis of blood or respiratory gases, or alternatively exposure of subjects to appreciable doses of ionizing radiation for chest fluoroscopy with subsequent film development and analysis. The objective of this effort is to develop a microwave attenuation measurement capable of detecting changes in cardiac output in adverse Air Force environments without disturbing the subject. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0043 ELECTRICAL & ACOUSTIC PROPERTIES OF BIOLOGICAL MATERIAL. Schwan, H. P.; Takashima, S.; Fischler, H.; Schwartz, G. (Univ. Pennsylvania, Sch. Engineering & Applied Science, 4001 Spruce St., Philadelphia, PA 19104).

This research will investigate the electrical and acoustic properties of biological materials and related problem areas such as electrode polarization and forces induced by alternating electrical fields acting on biological particles. Present and future emphasis will be on: (1) The behavior of electrodes used for impedance measurements and excitation purposes in physiology and cardiology (pacemaker) in frequency and time domain with particular emphasis on their nonlinear characteristics. (2) Electrical characteristics of macromolecules and water bound to their surface. (3) Electrical characteristics of biological and artificial cells and membranes as related to their structure and function. (4) Acoustic properties of tissues and biological macromolecules and the reasons why their specific absorption varies so considerably from one type to another. (5) Field induced force effects; particularly alternating field induced forces acting on biological cells and of significance either from a hazard point of view or with a potential for new biological research techniques. (10/75-9/76)

Supporting Agency:HEW, PHS, NIH

0044 COMBINED STRESS STUDIES IN HF BAND FIELDS. Cupello, J. M. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Exposure of Air Force personnel to radiofrequency radiation environments can produce an added stress to the thermal regulatory system. Existing exposure standards are based on the extent to which this stress can be tolerated. This effort will evaluate biologic responses under combined temperature and radiofrequency radiation stress. Plexiglass environmental chambers for holding experimental animals during radiofrequency radiation exposure are being designed and constructed. These chambers will allow control of the temperature and relative humidity of the air surrounding the animals. The effects of heat stressing the animal during exposure to radiofrequency radiation, thereby overburdening his heat dissipation mechanism, will indicate the effect of combined stress in radiofrequency fields. Monitoring the chambers' input and output temperature with relative humidity will allow quantitation of the amount of heat generated in the rate due to radiofrequency exposure. Larger chambers will be constructed at a later date to perform this same study on rhesus monkeys. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0045 THE EFFECTS OF LOW POWER DENSITY ELECTROMAGNETIC ENERGY ON BIOLOGICAL SYSTEMS. Flanigan, W. F.; Ridgway, S. H. (U.S. Navy, Biosystems Research Dept., San Diego, CA 92132).

The objective of this project is to study the electrophysiology (i.e., brain wave activity, heart rate) and behavior of reptiles (turtles) exposed to low power density ($\leq$ 10 mW/cm^2) electromagnetic radiation at a number of frequencies within a range of 0.1-10 GHz. Nonmetalic electrodes will be developed to enable both EEGs and ECGs to be recorded from the brain and heart, respectively, of acute and chronically implanted animals. All field exposure experiments will be conducted in air. Acutely implanted turtles will be anesthetized and restrained. EEGs and ECGs will be simultaneously recorded. Chronically implanted animals will be prepared using a standardized procedure. Each animal will serve as its own control. Baseline recordings prior to any field exposure will be compared with those obtained when an animal is exposed to electromagnetic radiation. Cumulative effects of recurring field exposure will be investigated by comparing baseline recordings to recovery recordings made between periods of irradiation as well as by comparing subsequent field exposure recordings with prior field exposure recordings. Baseline field exposure recovery recordings will range from a fraction of a second to hours for acute preparations and minutes to days for chronically implanted animals. Electrophysiological techniques will be employed including spectral analyses of EEGs and averaged cortical evoked potentials using a computer of averaged transients to determine sensitivity to electromagnetic radiation. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0046 COMPARISON OF RF FIELD DELIVERY TECHNIQUES AND MEASURABLE RESULTS IN CELL CULTURE AND WHOLE ANIMALS. Guy, A. W. (Univ. Washington, Sch. Medicine, C304 Health Sciences Building, Seattle, WA 98105).

High level national concern over the adequacy of existing radiofrequency safety standards has highlighted the need to define experimental exposure fields accurately, insure intercomparability of power deposition and mechanism of injury studies and validate theoretical predictions with measured distributions in experimental animals. This effort will investigate ground plane and position effects on power absorption in several man models at the University of Washington and at USAFSAM/RA. Investigators will intercompare field measurement techniques used at the University of Washington and those used at USAFSAM, and compare the theoretical and measured distributions in experimental animals exposed in both facilities. In addition, an exposure system will be designed and constructed for cell or tissue cultures when fields within culture can be exactly specified. Investigators hope to demonstrate the utility of the culture system by exposing freshly isolated primate lymphocytes with and without simulating antigens. University of Washington personnel are to bring thermographic equipment and field measurement devices to USAFSAM to compare their measurements with those at USAFSAM. Killed animal models and physical models are to be examined after exposure to a variety of frequencies generated by the HF band coax, near field synthesizer and the University of Washington resonant cavity at USAFSAM and at the University of Washington. Fields generated by the multiple frequency exposure apparatus will also be provisionally examined at SAM. An exposure cell is to be constructed from readily available materials, and its utility

demonstrated by exposure of freshly isolated lymphocytes to fields calculated for an equivalent field in man models exposed to a variety of field geometries. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0047 NAVY ENVIRONMENT: EVALUATION OF THE SAFETY EXPOSURE LIMITS OF RADAR USED BY NAVAL PERSONNEL. Hunt, E. L.; Phillips, R. D. (Battelle Memorial Inst., P.O. Box 999, Richland, WA 99352).

Naval personnel exposed to the powerful electromagnetic radiation of radar on shipboard may suffer possible nervous side-effects as a result of long-term exposure, which are not immediately apparent. This research is designed to test for possible ill effects of chronic low-level microwave exposure. Studies will be limited to behavioral and neurophysiological investigations for the detection and characterization of effects that might be produced by short term exposure to pulsed microwaves at low power levels (10 mW/cm^2 or less average power), or following chronic exposures to pulsed microwaves at low average levels. Discrimination performances will be tested using operant conditioning procedures. One test will look for a disturbance in the level of performance following exposure. Another will look for disturbances in the learning of a simple discrimination task. Research will continue attempts to verify the avoidance by rats of the pulsed microwave field. In addition, susceptibility to sound-induced seizures will be studied in sensitive and insensitive mice following exposure to pulsed microwaves in a series of daily 3-hour exposures. (7/75-6/76)

Supporting Agnecy:U.S. Dep. Def., Navy.

0048 TO DESIGN AND STUDY THE EFFECTS OF BIOMEDICAL SYSTEMS ON ANIMALS. Dracy, A. E.; Sander, D. E.; Busch, L. F. (South Dakota State Univ., Agricultural Experiment Station, Brookings, SD 57006).

The threefold objectives of this study are: (1) to design and test the validity of a volume conduction system for measuring body temperature continuously, (2) to study the effects of microwaves for partial and complete sterilization of farm animals, and (3) to design and test a unit, which will have an exciting effect on rats and mice. The latter will also be used for rodent control. The stated approach is to use the circuitry built during the school year and improve on the water stability problems as they affect the operation of the circuit; implant and monitor temperatures of the internal organs of the animal; build a microwave cavity and obtain equipment to irradiate safely the testicles of a sheep; and irradiate the subject and test the amount of sterility as a function of radiation power and time of exposure. In addition, investigators will design and build a power supply from existing sources and test the effectiveness of the sound source on the eradication of rats and mice. To date, a low-power, three channel telemetry system has been designed, built, and laboratory tested. This telemetry system transmits temperature, respiration, and electrocardiogram data simultaneously to an FM receiver-cassette tape recorder combination. The data are then transferred to the laboratory to be demodulated and analyzed. The circuitry utilizes low power amplifying multiplexing and modulation circuits as well as a low power transmitter. The entire transmitter package is housed in butal cement and nontoxic silicone rubber for implanting. Electrodes for the ECG, a thermistor probe for temperature, and a strain gage mounted on a three-inch metal fulcrum for respiration are attached to the transmitter via connecting wires. The life-time of the present system is about 60 days with the batteries used. The entire system was designed to gather data to determine excitability and state of emotional excitement in animals when exposed to different noises and sounds. It is known that heart rate, temperature, and to a lesser degree, respiration rate is affected by excitement stimuli. (7/75-6/76)

Supporting Agency:South Dakota State Govt.

0049 ELECTROMAGNETIC RADIATION AND BIOLOGICAL SYSTEMS. Bawin, S. M.; Adey, W. R.; Medici, R. J.; Walter, D. O. (Univ. California, Sch. Medicine, 405 Hilgard Ave., Los Angeles, CA 90024).

The study of the effects of electromagnetic radiations (450 MHz, amplitude modulation 0-90%, 0.1-10 mW/cm^2) on behavioral performances and brain neurochemistry of laboratory animals, (monkeys, cats, and chickens) will be continued, using the field exposure techniques developed and tested in this laboratory during the 1974-75 research period. Internal dosimetry studies and development of recording electrodes will be pursued in chronically and acutely exposed preparations. Theoretical models of brain tissues will be developed to provide a basis for interpretation of the experimental results and possible new designs of brain tissue simulation. (12/75-11/76)

Supporting Agency:HEW, PHS, FDA, Bur. Radiol. Health.

0050 NAVY ENVIRONMENT: EFFECTS OF MICROWAVES ON MATURATION IN THE RAT. Michaelson, S. (Univ. Rochester, Sch. Medicine & Dentistry, 601 Elmwood Ave., Rochester, NY 14642).

Research to date has shown that microwaves affect the growth and development of the rat fetus when the exposure is properly placed during the gestational period. Brain growth appears to be most affected. This research will attempt to study how subsequent neo-natal development and maturation of temperature regulation, which involes neural, hormonal and mutational facets, are modified by the *in utero* exposures. The development of the brain and ontogeny of temperature will be studied by exposing individual rats (previously exposed *in utero*) of specific ages to a mild cold stress (25-30° C) and measuring metabolism (O_2 consumption) and peripheral venous vasoconstriction. If a deficit appears, substrate, hormonal or neural factors which may be responsible will be examined. Some animals will be decapitated for gross and microscopic examination of the brain. During the second

year, power density/time relationships will be developed on the basis of body surface. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0051 CLINICAL ASPECTS OF MICROWAVE EXPOSURE. Michaelson, S. M. (Univ. Rochester, Sch. Medicine & Dentistry, 601 Elmwood Ave., Rochester, NY 14642).

Evaluation of alterations in the functional status of the neuroendocrine system after exposure to microwaves and elucidation of threshold levels, cumulative effects, interaction with other stresses and environmental factor is the objective of this study. Mature rats will be exposed to microwave irradiation in three different regimens: 100 mW/cm^2, 10 mW/cm^2, and 1 mW/cm^2 for eight weeks. Periodically throughout the exposure, body weight and temperature will be taken, and blood drawn. Gross behavioral observations will also be made. Thyroid function will be evaluated using T3 and T4 resin sponge absorption studies. Pituitary function will be determined by a bioassay of TSH. Mature dogs also will be exposed to microwave irradiation. Evaluation of changes in body weight, temperature, behavior, thyroid and pituitary function will be carried out as with the rats. In addition, hematology, clinical chemistries, free T4TSH, and growth hormones will be studied by radioimmunoassay and serum electrophoresis. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0052 AN INVESTIGATION OF THE EFFECT OF MICROWAVES ON ISOLATED NEURONS. Wachtel, H.; Joines, W. (Duke Univ., Sch. Arts & Sciences, Durham, NC 27706).

The effect of microwave irradiation on the neurons of the marine mollusc *aplysia* will be investigated. Special emphasis will be given to the pacemaker cells which exhibit regular firing patterns in the absence of external stimulation. A neuron from the abdominal ganglion of *aplysia* is pined out in a small chamber that is inserted into a microwave strip line. The neuronal activity is monitored with intracellular microelectrodes. Both incident and reflected power are recorded. Theoretical, as well as experimental, determinations of the absorbed power are made. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0053 EFFECTS OF NON-IONIZING ELECTROMAGNETIC RADIATION ON SUBCELLULAR PREPARATIONS. Straub, K. D. (Univ. Arkansas, Sch. Medicine, 4301 W. Markham St., Little Rock, AR 72201).

The effect of extremely low frequency and microwave radiations on the subcellular preparations responsible for active transport and oxidative phosphorylation will be explored. Microsomal (cell membrane) (Na^+ and K^+) ATPase from several sources (ox brain, rat brain, gar olfactory nerves, and invertebrate peripheral neurons) will be exposed to both ELF-VLF (10 Hz-30 kHz), VHF-UHF (30-300 MHz) and microwave radiation (1-12 GHz) in specially constructed cells. Various parameters of this membrane preparation including K_m and V_{max} for Na^+, K^+, and Mg^{++} and ATP, ubain sensitivity and lipase activation will be measured. Fluorescent probes of membrane structures will be used to assess the extent of change in membrane conformation. Simultaneously, rat liver and rat brain mitochondria will be exposed to these frequencies using the same exposure cells. The O_2 consumption, ADP/O ratios, state 3-4 transition, control ratios, swelling and shrinking, and state of electron carriers will be measured. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0054 EFFECTS OF NON-IONIZING RADIATION ON BIOMEMBRANES AND BIOLOGICAL MACROMOLECULES. Sheridan, J. P.; Weiss, J. A. (U.S. Navy, Research Lab., Washington, DC 20390).

This Navy program will investigate the possible effects of non-ionizing radiation of living organisms. The objective of this research is to determine the effects of pulsed and continuous wave non-ionizing electromagnetic radiation on biomembranes and biological macromolecules. By obtaining data on these interactions at the molecular level it should be possible either to substantiate or refute the possible implications of low level effects and aid in establishment of a safety level with sound and comprehensive scientific backing. The structural properties of various model membrane systems under the influence of low to moderate power non-ionizing electromagnetic radiation will be studied using raman spectroscopy, fluorescence spectroscopy, and microcalorimetry. The frequency dependence of any observed effects will be investigated over the 100 MHz-20 GHz spectral region using both pulsed and continuous wave sources. These studies will serve as the basis for the investigation of real biological membranes and other biologically active and accessible membrane structures. Concurrent with these studies, the effects of electromagnetic radiation on biological macromolecules including polypeptides, proteins and polynucleotides will be examined. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0055 BIOCHEMICAL EFFECTS OF MULTIFREQUENCY MICROWAVE RADIATION. Reno, V. R.; Beischer, D. E. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

Biochemical studies will be conducted in primates as an index of effects of microwave radiation on naval personnel. Subhuman primates will be exposed to pulsed and continuous wave microwave radiation in the range of 1-30 mW/cm^2 for extended periods. Radiation frequencies of 1-12.4 GHz will be used and the polarization varied to identify frequency and polarization specific effects. Serial blood sampling procedures will provide material for biochemical and hematological analysis. Results will be statistically

correlated with the radiation parameters and other significant physical factors, such as, the ratio of the animal size to the wavelength of the radiation. The observed biochemical and hematological changes will be considered in relation to other studies conducted under the same conditions. This new work unit continues previously performed research. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0056 RADIOFREQUENCY RADIATION EFFECTS ON BIOCHEMICAL SYSTEMS IN THE CENTRAL NERVOUS SYSTEM. Merritt, J. H.; Frazer, J. W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

The Air Force has an on-going research and development effort to evaluate the biological effects of radiofrequency radiation associated with planned or operational radar systems. This effort will evaluate "near field" exposures representative of those associated with the 414L OTH radar system. Data will be applied to Air Force safety criteria for this and other systems. The study will evaluate the effects of radiofrequency radiation on those biochemical events subserving and associated with neural impulse transmissions in the central nervous system. Simultaneous estimations of 5-hydroxyindoleacetic acid, homovanillic acid, norepinephrine, dopamine, and 5-hydroxytryptamine will be made in discrete brain areas of rats exposed to radiofrequency fields. Preliminary studies of the effect of a defined electrical stimulus and hyperthermia on the levels of these transmitters will be made. After preliminary data have been obtained, the effect of "far field" conditions (19 MHz) at both continuous wave and pulsed modes on the neurotransmitters will be determined. The same studies will be done using animals exposed on the SAM "near field" simulator. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0057 REFLECTION AND DIFFRACTION ASPECTS OF BIOLOGICAL MICROWAVE DOSIMETRY. Reno, V. R.; Beischer, D. E. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

Procedures will be developed to provide new insight into the energy absorbed from microwave fields by living systems to estimate validly the effects of microwave energy on naval personnel. Reflection and diffraction studies will be performed, with the ultimate objective of estimating absorption of microwave energy from information contained in the spatial and amplitude distribution of energy in proximity to illuminated objects. Holographic procedures are among those that will be applied to data from field scans taken near animals and objects of different shape and composition. This is conceptually a new approach that may provide an improved, noninvasive method for estimating the absorption of microwave energy by living organisms. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0058 MICROWAVES. Anonymous. (Natl. Scientific Res. Center, 15 Quai Anatole, Paris, France 75700).

Microwaves have significant effects on materials and biological substances. This study will investigate the effects of microwaves and thermal treatments on industrial materials in addition to the effects of microwaves on insects and microorganisms. (7/75-6/76)

Supporting Agency:Natl. Sci. Res. Ctr., France.

0059 NAVY ENVIRONMENT: BIOMEDICAL EFFECTS OF RADIO FREQUENCY RADIATION. Lin, J. C.; Kraus, G. E. (Wayne State Univ., Sch. Engineering, 5950 Cass Ave., Detroit, MI 48202).

As a major user of electromagnetic radiation, especially in the area of communication in the UHF to VHF portion of the spectrum and having many potential human exposure situations, the Navy is attempting to establish a sound basis for exposure standards. This research will be a part of the effort to determine the potential for hazard in the frequency range of 50-300 MHz. This study will investigate the effect of radiofrequency radiation on the growth, reproduction, and pathology of mice. The mice will be exposed, both acutely and chronically, in a parallel strip transmission chamber where plane wave fields with variable E/H ratios can be produced. Temperature distribution and patterns will be used to establish correlations. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0060 OCULAR EFFECTS OF MICROWAVE RADIATION. Carpenter, R. L. (U.S. Dept. Health, Education & Welfare, Public Health Service, Food & Drug Admin., Winchester, MA 01890).

The objective of this project is to determine the threshold conditions for the production of microwave induced cataracts and to uniquely characterize these cataracts. The effect of frequency, dose regimen and pulsing on the threshold for cataract formation in rabbits will be investigated. Biochemical and histopathological examinations of microwave irradiated lenses will be made to determine if microwave induced cataracts differ in any characterizable manner from cataracts of other etiologies. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0061 PROSPECTIVE EPIDEMIOLOGICAL STUDY TO EVALUATE NAVAL PERSONNEL OCCUPATIONALLY EXPOSED TO NON-IONIZING ELECTROMAGNETIC RADIATION. Blais, B. M.; Kelly, R. (U.S. Navy, Ophthalmology Dept., 17th & Pattison Ave., Philadelphia, PA 19145).

No descriptive information is available. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0062 MICROWAVE HEATING (MAMMALS). Guy, A. W. (Univ. Washington, Sch. Engineering, 206 Guggenheim Hall, Seattle, WA 98105).

See CR 0063 for description of this research. (10/75-9/76)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Gen. Med. Sci.

0063 MICROWAVE NERVE AND MUSCLE STIMULATION BY IMPLANTED DIODES (MAMMALS). Daniels, P. (Univ. Washington, Sch. Engineering, 206 Guggenheim Hall, Seattle, WA 98105).

This project is part of a broader program (GM 16436-08) conducted by the Center for Bioengineering, which represents a multidisciplinary research program involving faculty and students from all the departments of engineering engaged in collaborative research with health scientists from many medical and dental disciplines. Teams of investigators have been mobilized and organized to attack more than seventy projects of mutual interest ranging from the most basic "bioengineering science" problems to instrumentation and clinical engineering applied directly to patients. In accordance with carefully conceived plans, these individual collaborative research efforts have now been organized into eight groups, with common research objectives, facilities, requirements, budgets, and a responsible investigator. This major effort has been built upon a small central management including accounting, purchasing, central shop, and inventory control. The success of this effort is attributable in part to a few basic policies: (1) the Center supports existing department programs and does not dilute or compete with them, (2) the participants must have clear professional benefits from the program, (3) the engineers and life scientists must work as equal partners, (4) the future of biomedical research resides at the interface between disciplines. The Center for Bioengineering also serves as an interface between the University and the community, nurturing interaction with extramural medical research laboratories, not-for-profit research and development laboratories, local industry, medical centers and the community at large. By these means a comprehensive effort is directed toward transferring the fruits of biomedical engineering research and development to the health care delivery system. (10/75-9/76)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Gen. Med. Sci.

4500 EFFECTS OF MICROWAVES ON THE TWENTY-FOUR HOUR RHYTHM AND TWENTY-FOUR HOUR URINARY EXCRETION OF SEVENTEEN HYDROXYCORTICOIDS AND SEVENTEEN KETOSTEROIDS (SYMPOSIUM SUMMARY). (Eng.) Szady, J. (Postgraduate Medical Center, Military Medical Acad., ul Szsaserow 128, Warszawa 60, Poland); Siekierzynski, M.; Dziuk, E.; Jedrzejczak, W. W.; Czarnecki, C. *J. Microwave Power* 11(2): 139-140; 1976.

The urinary excretion of 17-hydroxycorticoids (OHCS) and 17-ketosteroids (KS) was determined in subjects exposed to microwave radiation. Investigations were carried out in two groups. Group I comprised 12 male subjects aged 20-22 years, working under exposure to microwave radiation pulse-modulated at different frequencies, used in radiolocation and at a mean energy beam density of 2-60 W/m^2. Group II (control) contained 15 males of the same age not exposed to microwave radiation. In all subjects the urinary excretion of 17-OHCS (Porter-Silber method) and 17-KS (Norymberski-Zimmerman method) was determined, and changes in the 24-hour rhythm of excretion of these hormones were analyzed. The determinations were performed at four-period time intervals during 48 hours, i.e., on a workday and the following day. The results failed to demonstrate differences in 17-OHCS and 17-KS excretion between these groups, and the 24-hour rhythm of excretion of these hormones corresponded to the normal physiologic rhythm. (No refs.)

4501 COMPARATIVE STUDY OF THE ACTION OF THREE TYPES OF MICROWAVE FIELDS UPON THE BEHAVIOR OF THE WHITE RAT (SYMPOSIUM SUMMARY). (Eng.) Servantie, B. (Ecole d'Application du Service de Sante pour la Marine--Centre d'Etudes et de Recherches Biophysiologiques appliquees a la Marine, 83800 Toulon Naval, France); Gillard, J.; Servantie, A. M.; Obrenovitch, J.; Bertharion, G.; Perrin, J. C.; Creton, B. *J. Microwave Power* 11(2): 145-146; 1976.

Behavioral perturbations induced in the white rat were studied after two weeks exposure to 2.45 GHz continuous wave field, 9.4 GHz, 0.15 µsec, 2000 Hz and 9.4 GHz, 0.5 µsec, and 1000 Hz microwave fields. Rats were first exposed to a 9.4 GHz field modulated with 2000 Hz, 0.15 µsec pulses, with a low average power density (0.7 mW/cm^2). Their behavior was modified: in control animals, locomotor activity, emotivity, and watchfulness decreased during the test, while exploratory activity increased; in irradiated animals, locomotor activity remained uniform, watchfulness at first increased then decreased, and exploratory activity increased more slowly. The same test was used to compare the action of three different fields: a 2.45 GHz continuous wave field with a power density of 5 mW/cm^2; a 9.4 GHz pulsed field with 0.15 µsec pulses, 2000 Hz pulse repetition frequency, and an average power density of 0.7 mW/cm^2; a 9.4 GHz pulsed field with 0.5 µsec pulses, 1000 Hz pulse repetition frequency and an average power density of 0.7 mW/cm^2. After 15 days of exposure to a field the rats were subjected to the test. The 2.45 GHz continuous wave field and the 9.4 GHz 0.15 0.5 µsec pulsed field produced only weak alterations. behavioral alterations; on the contrary, the 9.4 GHz µsec pulsed field produced only weak alterations. The theoretical values of the fields into the rat head were computed using data from the literature. It is postulated that the action of microwave fields on the behavior of rats is linked to the peak power density and not to the average power density. Moreover, this action seems to be independent of the modulation of the field. (No refs.)

4502 BIOLOGICAL MEASUREMENTS IN RODENTS EXPOSED CONTINUOUSLY THROUGHOUT THEIR ADULT LIFE TO PULSED ELECTROMAGNETIC RADIATION. (Eng.) Baum, S. J. (Armed Forces Radiobiology Res. Inst. Defense Nuclear Agency, Bethesda, MD 20014); Ekstrom, M. E.; Skidmore, W. D.; Wyant, D. E.; Atkinson, J. L. *Health Phys.* 30: 161-166; 1976.

Possible late effects in Sprague-Dawley rats continuously exposed to a total of 2.5 x 10^8 pulses of electromagnetic pulse (EMP) for 94 weeks of their adult life were investigated. The EMP generator produced 5 pulses/sec for 2.5 x 10^8 pulses and a maximum electric field strength of 447 kV/m. Blood chemistry, chromosomal damage, red blood cell production, fertility and reproductive capabilities, blood and bone marrow cellular concentration, and appearances of tumors or other defects were monitored. Exposed rats and controls showed no differences in nucleated bone marrow. The final combined mean number of nucleated cells/mm^3 of bone marrow was 8.1 x 10^5 ± 10^5. Early in the study exposed rats showed an increase in the number of reticulocytes, but this difference disappeared in the last 25 weeks of the study. The incidence of tumors was similar for both groups. Rat pairs exposed to 3.4 x 10^7 EMP showed no loss of fertility and no anatomic abnormalities were recorded for progeny. In effect, EMP was believed to pose no biologic hazard to the rodents, although it is difficult to prove that minute somatic changes had not occurred that could be of future deleterious consequences. (9 refs.)

4503 EFFECTS OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS ON *PHYSARUM POLYCEPHALUM*. (Eng.) Goodman, E. M. (Univ. Wisconsin-Parkside, Kenosha, WI 53140); Greenebaum, B.; Marron, M. T. *Radiat. Res.* 66(3): 531-540; 1976.

Effect of extremely low frequency (ELF) electromagnetic fields (EMF) was studied on microplasmodia of the slime mold *Physarum polycephalum*. Experiments included observations of vegetative growth, sphorulation or encystment, sexual life cycle, and protoplasmic streaming. Ten experimental plates (versus 10 controls) were continually subjected to a particular EMF, then the mitotic cycle ascertained by ethanol fixed smears. The ability of plasmodia to form spherules or to encyst was determined by pigment extraction. The ability of plasmodia to sporulate and germinate, and then fuse to form plasmodia was studied in experiments on the sexual cycle. Protoplasmic streaming was determined by the oscil-

latory period of four streaming channels and choice of 4-10 channels per culture. ELF EMF exposures of 75, 60, and 45 Hz, 2.0G, 0.7 V/m caused lengthening of the mitotic cycle and slowing of shuttle streaming at 14, 90, and 120 days of exposure, respectively. These results may indicate that mitotic delay is frequency dependent. Delay in cycle may be due to interference with the mitotic cycle. Threshold intensities for affect are between 0.4 and 2.0 G, and 0.15 and 0.7 V/m. Mitotic delay is reversible. EMF had no significant effect on ability to form spherules or encyst, but delay in nuclear division was noted. (17 refs.)

4504 USE OF 300-MSEC MICROWAVE IRRADIATION FOR ENZYME INACTIVATION: A STUDY OF EFFECTS OF SODIUM PENTOBARBITAL ON ACETYLCHOLINE CONCENTRATION IN MOUSE BRAIN REGIONS. (Eng.) Modak, A. T. (Univ. Texas Health Science Center at San Antonio, San Antonio, TX): Weintraub, S. T.; McCoy, T. H.; Stavinoha, W. B. *J. Pharmacol. Exp. Ther.* 197(2): 245-252; 1976.

Microwave irradiation (300 msec) was used to inactivate cholinesterase and choline acetyltransferase to study the effects of sodium pentobarbital on acetylcholine concentrations in the brain of male Sprague-Dawley rats. Microwave irradiation of 6 kw at 2450 MHz for 300 msec was used to sacrifice mice and rats treated intraperitoneally with sodium pentobarbital (50, 80, 100 mg/kg). This technique rapidly causes irreversible inactivation of the brain enzymes. Not only did the enzyme levels remain close to *in vitro* levels, but the tissue was fixed, thus simplifying microdissection of the brain. The highest levels of acetylcholine were found in the striatum (81 nmol/g), while the cerebellum had the least (17 nmol/g). Increases of acetylcholine in the brain after treatment with sodium pentobarbital was found not to be due to hypothermia or anoxia. The drug caused an increase of acetylcholine in all areas of the brain studied, except the cerebellum, where there was a decrease. Central nervous system depression was correlated with high acetylcholine levels. When neuronal activity returned to normal, acetylcholine levels decreased. (31 refs.)

4505 SOME ASPECTS OF ETIOLOGICAL DIAGNOSIS IN OCCUPATIONAL DISEASES DUE TO THE ACTION OF MICROWAVE RADIATION. (Rus.) Gus'kova, A. K. (Inst. of Industrial Hygiene and Occupational Diseases of the U.S.S.R. Academy of Medical Sciences, Moscow, U.S.S.R.); Kochanova, E. M. *Gig. Tr. Prof. Zabol.* (3): 14-18; 1976.

Predisposing risk factors for cardiovascular diseases were analyzed in 21 men, aged 35-54 year, who had been occupationally exposed to intense super high frequency radiation for a prolonged time, and in whom radiowave sickness was diagnosed. The duration of the occupational exposure was over 10 years in 19 patients. Clinical examinations revealed hypertonic neurocirculatory dystonia in 7 patients, hypertension in 10 patients, ischemic heart disease in 2 patients, and hypothalamic insufficiency in another 2. A reexamination 2-3 years after the cessation of the occupational exposure showed no marked improvement. Among the risk factors predisposing to cardiovascular diseases were nervous-emotional stress, which was found in 14 cases, overload factors due to combination of work and study in 4 cases, night shifts in 17 cases, regular smoking in 7 cases, moderate alcohol consumption in 7 cases, moderate alcohol consumption in 7 cases, hereditary load in 5 cases, cranial trauma in the anamnesis in 3 cases, overweight in 5 cases, hypercholesterolemia in 12 cases, and arterial hypertension in 10 cases. Combination of 3-6 of the above risk factors was found in 10 patients. The findings indicate that microwave radiation may be one of the risk factors of cardiovascular pathology rather than a sole factor of the disease. (16 refs.)

4506 THE RELATION OF SEX, AGE, AND WEIGHT OF MICE TO MICROWAVE RADIATION SENSITIVITY. (Eng.) Rugh, R. (U.S. Dept. of Health, Education and Welfare Public Health Service, Food and Drug Administration, Bureau Radiological Health, 5600 Fishers Lane, HFX-120 Rockville, MD 20852). *J. Microwave Power* 11(2): 127-132; 1976.

Male and female CF_1 strain mice were irradiated to death to determine whether sex, age, or weight affected their sensitivity to microwave radiation. Weanling (one month old), sexually mature (two months old) and aged mice (fourteen months) were exposed to 2450 MHz radiation at 7.5 watts forward power. A total of 114 mice were used with a minimum of 14 per group. Results show that under the same radiation condition both sexes displayed an increase in time of death with increased age and weight. Time to death increased from 4.10-7.66 minutes for males and from 3.80-5.56 minutes for females. Absorbed dose in J/g at death rose slightly, but not significantly, with age for males (43.9-47.80) but declined slightly with age for females (42.90-39.30). The slight depression in absorbed dose at death for females is believed to be sex related and due to the physiological stress of bearing approximately 100 offspring. In the same sex group, the mean absorbed lethal dose was essentially the same for all ages and weights but differed considerably between the sexes. All males absorbed more microwave energy in J/g at death than comparable females, and therefore, are more radioresistive. Normal male mouse temperature was 37.9°C and 38.4°C for females. Lethal rectal temperature was >43°C. There was no evidence of change in radioresistance with age. (11 refs.)

4507 MODIFICATION OF THE REPAIR OF RADIATION DAMAGE OF HAEMATOPOIESIS IN MICE BY MICROWAVES (SYMPOSIUM SUMMARY). (Eng.) Rotkovska, D. (Inst. Biophysics, Czechoslovak Acad. Sciences, Brno, Czechoslovakia); Vacek, A. *J. Microwave Power* 11(2): 141-143; 1976.

Microwaves (2450 MHz, 100 mW/cm^2) were used to modify postirradiation repair of hematopoiesis in the mouse in an early period until 24 hours after whole-

body sublethal exposures to X-ray irradiation. Experiments were performed with C57Bl/10 strain mice subjected to whole-body irradiation with a sublethal dose of 600 to 750 R. The animals were irradiated with microwaves (100 mW/cm^2, 2450 MHz, 5 min) at different times until 24 hours after X-ray irradiation. A control group was exposed solely to X-ray irradiation. In contrast to the control group, the number of hematopoietic stem cell colonies in the spleen increased after combined irradiation, and the difference between the control and experimental groups became statistically significant ($p<0.01$) for the intervals of 30 minutes, 6 hours, and 12 hours. Increased repair of the radiation damage of hematopoiesis was also demonstrated by a higher percentage of ^{59}Fe incorporation in the spleen and a more rapid improvement of the peripheral indicators of hematopoiesis as compared with that of X-ray controls. On day 8 and day 20 after combined irradiation, the number of leukocytes in peripheral blood was twice that of controls. In addition, the microwave irradiation resulted in a prolonged mean survival period of the experimental groups as compared with controls. The results demonstrate that microwave irradiation can modify the course of repair processes in the hematopoietic stem cells in an early period following the exposure to X-rays. (No refs.)

4508 HUMAN AUDITORY SYSTEM RESPONSE TO LOWER POWER DENSITY PULSE MODULATED ELECTROMAGNETIC ENERGY: A SEARCH FOR MECHANISMS (SYMPOSIUM SUMMARY). (Eng.) Eichert, E. S. (Randomline, Inc., County Line and Mann Roads, Huntingdon Valley, PA 19006); Frey, A. H. *J. Microwave Power* 11(2): 141; 1976.

The human auditory system response to lower power density, pulse modulated, electromagnetic energy may provide a new tool to investigate the human auditory system and new insight into nervous system and behavioral effects. Several mechanisms, which have been suggested, were studied including thermally launched acoustic waves, direct neural stimulation, and direct interaction with portions of the auditory system. These proposals were considered in conjunction with the entire body of radio frequency-sound data. New data, particularly human responses to pulse pair and pulse train modulation, interferometric studies with animals, and reports of cochlear microphonics during ultra high frequency exposure were included in the analysis. Most of the suggested mechanisms were either difficult to test or inconsistent with available data. The models' success and failure as explanatory mechanisms are discussed, and additional lines of investigation are suggested. (No refs.)

4509 CYTOTOXIC EFFECTS OF ELECTROMAGNETIC RADIATION ON CHINESE HAMSTER CELLS IN CULTURE (SYMPOSIUM SUMMARY). (Eng.) Chen, K. C. (Dept. Biology, Wayne State Univ., Detroit, MI 48202); Lin, C. J. *J. Microwave Power* 11(2): 140-141; 1976.

The cytotoxicity of Chinese hamster cells produced after irradiation was demonstrated in terms of growth rate, morphological transformation, and colonizing capacity. By employing an improved fluid-filled wave guide exposure chamber originally designed by Lin and Chen (1975), the nonthermal effect of 2450 MHz microwave radiation on Chinese hamster cells in culture was demonstrated. The differential effects of microwave radiation on Chinese hamster cells were examined as a function of the position of the cell within its generation cycle. The cytotoxicity of the cells produced after irradiation was compared over a 12-day incubation period. Although a clearcut cyclic response of mammalian cells to microwave radiation could not be established, the results with Chinese hamster cells indicate that the growth rate of irradiated cells showed a decrease of 10-60%, depending on the level of the microwave exposure. Consistent with previous observations, a great number of the "giant-ruffle cell" transformations were seen when a high level of incident power density of microwave was applied. Such microwave-induced morphological transformations in the Chinese hamster cell appeared to be irreversible. (No refs.)

4510 INFLUENCE OF PULSED MICROWAVES ON HAEMATOPOIESIS OF ADOLESCENT RATS (SYMPOSIUM SUMMARY). (Eng.) Pazderova-Vejlupkova, J. (Clinic of Occupational Diseases, Charles Univ., Prague, Czechoslovakia); Frank, Z. *J. Microwave Power* 11(2): 139; 1976.

Pulsed electromagnetic fields caused a transient decrease of weight increment, hematocrit, and alkaline phosphatase activity in the course of intermittent irradiation of growing rats. Twenty male rats (initial average weight 65.53 g) were irradiated for seven weeks (5 days/week, 4 hours/day) by pulsed electromagnetic fields with the following parameters: working frequency 2736.5 MHz, repetition frequency 395 Hz, pulse width 2.6 μsec, polarization vertical, mean power density 24.4 mW/cm^2 (accuracy of measurement ± 6). The rectal temperature of the irradiated animals increased an average of 0.3°C after 3 hours of irradiation. The weight, hematocrit, leucocyte count, differential count, leucocyte alkaline phosphatase activity, and nucleoli of lymphocytes of the irradiated rats were compared with findings in 20 controls. After the first week of irradiation the weight increment was significantly lower, persisting for one week after the irradiation. The hematocrit was lower in the middle of the irradiation period and during the first month after exposure. After the beginning of the fourth week of irradiation the average leucocyte count was lower due to the decrease of the absolute number of lymphocytes. Recovery took place 2 months after irradiation. The alkaline phosphatase activity was lower at the end of irradiation only. All the differences presented were in the 1% level of significance. (No refs.)

4511 HUMAN THERMAL LOADING BY EXPOSURE TO EMISSIONS FROM A MICROWAVE OVEN (SYMPOSIUM SUMMARY). (Eng.) Prucha, R. V. (Range Component Engineering, General Electric Company, Building 2, Room 248, Louisville, KY 40225). *J. Microwave Power* 11(2): 160; 1976.

Thermographic measurements in full scale human phantoms exposed to emissions from a microwave oven were used to calculate temperature rise in a thermal model of the human body. Full scale phantom models of a two-year-old child and a woman were exposed to emissions from a forced leak in a microwave oven. The operating frequency was 915 MHz. Thermographic analysis using the technique developed at the University of Washington and reported in a companion paper by A. W. Guy provided data on specific absorption rate (SAR) and identification of the heating pattern. These data, which relate to the defined leakage source intensity, were used as the basis for heat input and temperature rise calculations in thermal models of humans. Both worst case and typical case calculations based on movement patterns were made and the results were compared with those produced by other heating means, such as, changes in metabolic rate (deep heating) and exposure to normal sunlight (surface heating). Results also were compared with medical diathermy practice. These results show the very conservative nature of the current microwave oven emission standards. (No refs.)

4512 EFFECT OF MICROWAVES ON VIRUS MULTIPLICATION IN MAMMALIAN CELLS *IN VIVO* AND *IN VITRO* (SYMPOSIUM SUMMARY). (Eng.) Luczak, M. (Center of Radiobiology, Radioprotection, 00-909 Warsaw, Poland); Szmigielski, S.; Janiak, M.; Kobus, M.; de Clerq, E. *J. Microwave Power* 11(2): 173-174; 1976.

It has been suggested that microwaves at subthermal field power densities may influence multiplication of virus particles *in vitro*. Experiments on virus multiplication *in vitro* were performed using WISH cells (continuous line of human embryonic cells) and myxovirus para-influenza 3. The cell cultures were irradiated with 3 GHz microwaves at far field conditions in anechoic chambers (30 minutes) at field power densities 5 or 20 mW/cm^2. Inoculation with viruses (0.01 $TCID_{50}$/cell) was performed 2 hours before, simultaneously, 2, or 24 hours after irradiation with microwaves. Irradiation of cells at a field power density of 5 mW/cm^2 resulted in an increase of virus multiplication in cultures inoculated 2 hours before, simultaneously, or 2 hours after inoculation. This suggests that the increased multiplication is due to stimulation of cell metabolism (protein and nucleic acid synthesis). Irradiation of WISH cells at 20 mW/cm^2 resulted in lowered multiplication of viruses in cells irradiated at 2 hours before or after inoculation. In cultures irradiated 24 hours after inoculation normal multiplication of viruses was found. *In vivo* experiments were performed on young CFW mice infected intravenously with vaccina or Herpes viruses. The animals were irradiated for 7 days postinfection (3 GHz microwaves, anechoic chamber, far field conditions, field power density 40 mW/cm^2, 2 hours daily). Several of the infected and irradiated animals were additionally injected with Cytosar or cytosine arabinoside (ARA-C). The results indicate that irradiation with microwaves influenced the course of viral infections in mice, the effect being dependent on the schedule of irradiation. Exposure to microwaves after infection resulted in lowered multiplication of Herpes viruses (as measured by number of lesions on tails) and enhanced the inhibiting effect of Cytosar and ARA-C. (No refs.)

4513 MICROWAVE THERAPY AND MUSCLE BLOOD FLOW IN MAN (SYMPOSIUM SUMMARY). (Eng.) McNiven, D. R. (Physiotherapy Dept., Inst. Neurological Sciences, Southern General Hosp., Govan Road, U.K.); Wyper, D. J. *J. Microwave Power* 11(2): 168-170; 1976.

The effect of microwave therapy on muscle blood flow in man was studied. Five healthy subjects (3 male and 2 female), in the age range 20 to 40, were investigated. Muscle blood flow was measured using the xenon-133 clearance technique. Xenon-133 (200 μCi) dissolved in 0.1 ml of sterile isotonic saline was injected into the muscle (vastis lateralis). A scintillation counter was used to monitor the count rate. A single injection of xenon-133 was used to measure muscle blood flow at rest, during application of the microwave therapy, and during static exercise. Once a steady value was obtained for the resting flow, the microwave apparatus (2450 MHz) was switched on, with the power output adjusted to produce the maximum comfortable heating. After about 8 minutes, the slope of the clearance curve was observed to increase, indicating an increase in muscle blood flow. On obtaining a new steady value, the apparatus was switched off. Flow was maintained at the higher level for about 5 minutes before gradually decreasing. The investigation was concluded by the subject performing static quadricep contractions. A highly significant increase in muscle blood flow was produced in all subjects; the mean values being 2.9 ml/100g/min at rest and 11.4 ml/100g/min at the end of microwave application. No significant correlation was found between athletic fitness and blood flow or between resting blood flow and the time delay between the start of microwave application and the blood flow increase; this varied from 5 to 12 minutes. (No refs.)

4514 ACUTE MICROWAVE IRRADIATION AND CATARACT FORMATION IN RABBITS AND MONKEYS (SYMPOSIUM SUMMARY). (Eng.) Kramer, P. (U.S. Public Health Service Hosp., Seattle, WA); Guy, A. W.; Emery, A. F.; Harris, C. *J. Microwave Power* 11(2): 135-136; 1976.

The special characteristics of the leakage field from an imperfect microwave oven were investigated. Effective power density (EPD)/time levels were chosen as single, acute exposures in adult New Zealand rabbits to determine the cataractogenic threshold, using the near field of the 2450 MHz slot applicator. In all cases the right eye was irradiated, while the left eye served as the control. The lowest cataractogenic level was found with an EPD level of 180 mW/cm^2 applied for 140 minutes with a peak specific absorption rate (SAR) level of 99.4 W/kg. Within one to two days following radiation, typical posterior cortical banding was found with the biomicroscope. SAR patterns in two young-adult rhesus monkeys were determined by placing the hori-

zontally oriented dipole with its center 5 cm from the bridge of the nose. Although peak SAR in the eye was again found in the lens (2.9 W/kg/W), less power was abosrbed in the monkey than in the rabbit (5.4 W/kg/W). An additional SAR pattern was determined in one monkey with the slot centered over one eye. Peak SAR in the eye was found in the lens, with relatively symmetrical surface heating of the periocular tissues. This SAR pattern may be used as a basis for determining the cataractogenic threshold in the monkey. (No refs.)

4515 EFFECT OF MICROWAVES COMBINED WITH INTERFERON AND/OR INTERFERON INDUCERS (POLY I-POLY C) ON DEVELOPMENT OF SARCOMA 180 IN MICE (SYMPOSIUM SUMMARY). (Eng.) Szmigielski, S. (Center for Radiobiology, Radioprotection, 00-909 Warsaw, Poland); Luczak, M.; Bielec, M.; Janiak, M.; Kobus, M.; Stewart, W. E., II.; de Clerq, E. *J. Microwave Power* 11(2): 174-175; 1976.

Neoplastic cells are highly sensitive to elevated temperatures. The use of microwave radiation for cancer treatment by hyperthermia (choice of wave frequency, control of temperature, perspectives, and problems) is reviewed, and the experiments on tumor-bearing mice irradiated with 3 GHz microwaves in combination with cytostatics (Endoxan), high doses of vitamin A, stroptolysin S, or staphylococcal toxins are discussed. Mice with transplanted Sarcoma 180 were irradiated with 3 GHz microwaves (anechoic chamber, far field conditions, 40 mW/cm^2, 2 hr daily) during the whole period of tumor growth. Part of control (tumor-bearing) and irradiated animals were injected with interferon (highly concentrated mouse interferon 100 IU/g daily) or Poly I-Poly C (2 mcg/g, daily). Size and weight of tumors, as well as incorporation of tritiated precursors of nucleic acids and proteins and intracellular level of cyclic AMP, were checked 14 days after tumor transplantation. Irradiation with microwaves (general hyperthermia) inhibited tumor growth in about 25-30% of mice, while combination of microwaves with interferon and Poly I-Poly C led to inhibition of tumor growth in about 75% of animals. Mechanisms leading to tumor inhibition *in vitro* and *in vivo* by general and local hyperthermia were discussed, as well as perspectives in the use of microwaves for cancer treatment by intensive local hyperthermia (42-44°C). (No refs.)

4516 INFLUENCE OF MICROWAVES ON GENETICAL PROCESSES OF *ASPERGILLUS NIDULANS* (SYMPOSIUM SUMMARY). (Eng.) Baranski, S. (Military Inst. Aviation Medicine, 01-755 Warszawa, krasinskiego, 54 Poland); Debiec, H.; Kwarecki, K.; Mezykowski, T. *J. Microwave Power* 11(2): 146-147; 1976.

The influence of microwave radiation on the genetic processes of *Aspergillus nidulans* was investigated to determine whether microwave radiation at nonthermal power densities is mutagenic. *A. nidulans* was chosen for investigation, since it is a haploid under experimental conditions. As induced mutations are usually recessive, they are phenotypically noticeable in first generations only in the case of haploids. In addition, chromosomal mutations appear phenotypically as morphological changes in mycelium, which enables quick and easy detection of mutants. In this experiment, irradiation was performed in plastic containers at 2450 MHz, at power densities $\leq$10 mW/cm^2, for 10-240 minutes. The results do not show any mutagenic effects of microwaves. Currently, results of other experiments are being evaluated, in particular experiments in which different inhibitors of DNA repairing systems (e.g., caffeine) were used. (No refs.)

4517 EFFECT OF CONSTANT MAGNETIC FIELDS ON MACROMOLECULES. (Rus.) Miroshnichenko, F. D.; Stadnick, A. D. (Zaporozhe State Pedagogical Institute, Zaporozhe, U.S.S.R.). *Biofizika* 21(1): 178-179; 1976.

The exposure of discs of polymethylmetharcylate measuring 2 mm in thickness and 20 mm in diameter, previously heated to 100° in an electromagnetic field for 60 min led to a particular electretic state with a superficial charge density of about 10^{-10} Coulombs/sq cm, depending on the magnetic field potential. The appearance of charges was due to the orientation of the magnetically anisotropic macromolecules and their segments. The magnetic susceptibility, decreasing with time, increased with increasing field potential in a range of 0.0032-0.123 A/m. The decrease of the diamagnetic susceptibility is apparently due to the orientation process being accompanied by an increase in polarization paramagnetism. The changes in magnetic susceptibility explain some peculiarities of the mechanism of the effect of magnetic fields on biological objects. (3 refs.)

4518 MICROWAVE HEARING IN MAMMALS. (Eng.) Rissmann, W. J. (Dept. Electrical Engineering, Bioacoustics Res. Laboratory, Univ. Illinois, Urbana, IL 61801); Cain, C. A. *Natl. Electron. Conf. Proc.* 30: 239-244; 1975.

Threshold levels for the acoustic perception of microwaves were determined for the cat, dog, chinchilla, and several human subjects. Beckman type scalp electrodes (3 ohm impedance at 1000 Hz) were used to monitor auditory responses of nonhuman species. A speaker, and microwave generator were used as the stimulators. The restrained animal was exposed to speaker clicks and irradiated with 10 msec wide 3 GHz microwave pulses, both applied at a repetition rate of 0.5 Hz. The evoked responses appeared similar, except for a delay factor in the air conducted acoustic stimuli. No response was recorded when microwaves were replaced with a 50 ohm dummy load. The average energy density threshold for small mammals was 8.8 μJ/cm^2. Five of eight human subjects heard a click, which appeared to originate from in-

side the head when irradiated with a 15 msec pulse of 3 GHz microwave energy. The average threshold energy density level for humans was 10.5 $\mu J/cm^2$. Threshold levels seemed to be directly dependent upon the energy density per pulse rather than the peak power density per pulse. It is suggested that the differences in the human ability to detect microwaves was due to a hearing loss in a high frequency range that could not be tested. (15 refs.)

4519 NEUROENDOCRINE RESPONSE TO MICROWAVE IRRADIATION. (Eng.) Vetter, R. J. (Bionucleonics Dept., Sch. Pharmacy and Pharmacal Sciences, Purdue Univ., West Lafayette, IN 47907). *Natl. Electron. Conf. Proc.* 30: 237-238; 1975.

The effect of low level exposures to microwaves on the function of the neuroendocrine system was investigated. Pregnant rats were exposed for 15 days (days 6-21 of gestation) for 10 or 20 minutes to 0, 5, or 25 mW/cm^2 of 2450 MHz continuous wave microwave radiation. The rats were kept in an anechoic chamber with a -40 dB quiet zone. Blood samples were tested by radioimmunoassay for thyro-binding capacity. The results show that the thyro-binding ability of the blood serum increased with microwave exposure; thus thyroid hormone levels decreased. Results were inconclusive. First studies indicated a slight decrease in hormone levels and variance was high. Serum also was tested for protein transferrin by measuring serum iron and iron binding capacity. Protein levels increased with increasing energy exposure, indicating that protein synthesis was affected. Results show an attempt by the body to adjust to moderate temperature increases induced by microwaves (i.e., acclimatization). Further study is needed to determine whether the effects of long-term low level radiation (microwaves) are the results of adaptation or are subtle and dangerous effects. (6 refs.)

4520 EFFECTS OF MICROWAVES ON NORMAL AND TUMOR CELLS AS SEEN BY LASER-RAMAN SPECTROSCOPY (SYMPOSIUM SUMMARY). (Eng.) Webb, S. J. (Dept. of Physics, Univ. South Florida, Tampa, FL 33620). *J. Microwave Power* 11(2): 138; 1976.

The microwave absorption spectrum, between 50 and 200 GHz for tumor cells, differs from that of their homologous normal ones. The observed differences in the spectra of cells appear due to differences in the frequency constant that separates the absorbed frequencies in one or more of the series of frequencies absorbed by different cell types. Some *in vivo* energy states have been displayed as laser-Raman spectral lines from synchronized populations of cells. Many of these Raman lines are transient. Thus given that *in vivo* energy states are present, *in vivo*, only during specific stages of the cell cycle, this timed sequence of particular energy states seems to reflect the specific metabolic time clock of a given cell type. A study of the effect of exposure to various microwave frequencies on the time of appearance of given raman-shift lines has revealed that absorbed frequencies of 2-4 GHz increase the rate of the entire cell cycle. The exposure of cells to absorbed frequencies >50 GHz, however, does not increase the overall rate of the cell's metabolic time clock. All microwave effects seem to be frequency, or frequency series, specific and by far the most prevalent of them is the absence, in the raman spectrum of irradiated cells, of specific raman-shift lines. Thus, since tumor cells absorb frequencies that are not absorbed by normal cells, the metabolism of tumor cells may be selectively altered by their exposure to frequencies harmless to normal cells. (No refs.)

4521 EFFECT OF ELECTROMAGNETIC ENERGY ON THE FORMATION OF TRIGLYCERIDES: FREQUENCY INFLUENCE (SYMPOSIUM SUMMARY). (Eng.) Deficis, A. (Centre d'Etudes Recherches de Toulouse, Toulouse, France); Dumas, J. C.; Laurens, S.; Plurien, G. *J. Microwave Power* 11(2): 137-138; 1976.

A study was carried out on the effect of microwave frequency and power on the rate of formation of triglycerides in male Swiss mice. The authors tried to determine whether results, obtained at 2.4 GHz, would be duplicated at other frequencies between 2 and 10 GHz. Groups of 12 animals were placed in multimode cylindrical cavities of a 600 cm^2 cross section. Irradiations took place during 9 days (15 hours/day). The frequency between 2.4 and 9.4 GHz at 1.5 and 3.3 mW/cm^2 powers was investigated. Serum triglycerides were determined in 200 µl of serum by standard technique. Controls received infrared radiation. At 1.5 mW/cm^2 no difference was found between the triglycerides rate of the control animals and that of the animals exposed to microwaves, at any frequency. At 3.3 mW/cm^2 the triglyceride rate was the same in the control mice and mice exposed to microwaves at 2.9, 5.4, 9.4 GHz but significantly higher at 2.4 GHz. A study made at several power levels indicates that microwaves cause an increase in the rate of serum-triglycerides formation in mice at 2.4 GHz frequency. (No refs.)

4522 PULSED RADIOWAVE (27.12 MHz) EFFECTS ON *IN VIVO* AND *IN VITRO* TUMOR GROWTH (SYMPOSIUM SUMMARY). (Eng.) West, B. L. (Div. Medical Oncology, Box 273, Medical Coll. Virginia, Virginia Commonwealth Univ., Richmond, VA 23298); Regelson, W. *J. Microwave Power* 11(2): 176-177; 1976.

Inhibition of subcutaneous Lewis lung tumor was determined in BDF_1 mice after 23 daily 20-minute periods of exposure to a pulsed 27.12 MHz field. Mice were inoculated subcutaneously with 1×10^6 syngeneic Lewis lung carcinoma cells. Groups of eight mice were simultaneously irradiated at one of three different average power levels prior to tumor inoculation. Six groups received similar power levels of radiation immediately after inoculation. All groups were subsequently irradiated daily, twenty minutes per day, for 23 days. Significant reduction in tumor mass was observed in all postinoculated, irradiated groups. Measurement on postinoculation day 16 and 20 revealed a 60-90% inhibition of tumor mass when compared to controls. Pre-tumor inoculation radia-

tion demonstrated no change from control or an increase in tumor size. For both pre- and post-treated animals, no significant effects on survival were seen. An *in vitro* study was conducted to evaluate the response of tumor and normal cells to the same pulsed radiowave field. Each cell suspension, containing 1 ml (1×10^6 cells) was irradiated for twenty minutes. Post-radiation vital staining yielded a marked reduction of viability in 50-67% of all Lewis lung cells. In contrast, lethality for normal mouse embryo cells was 40%. In the case of Lewis lung tumor cells, the greatest lethality was observed in the cell suspensions experiencing the highest peak and average power outputs. L1210 leukemia cells obtained from DBA_2 mice were similarly processed and irradiated with a 60-90% lethality occurring, with toxicity directly related to the average power output. (No refs.)

4523 PHYSIOLOGICAL RESPONSES TO MICROWAVE EXPOSURE. (Eng.) Kinnen, E. (Dept. Electrical Engineering, Univ. Rochester, Rochester, NY 14627); Bogardus, R.; Lu, S.; Michaelson, S. *Natl. Electron. Conf. Proc.* 30: 233-236; 1975.

Five anesthetized dogs were exposed for 60 minutes to 60 mW/cm^2 incident power density at 2450 MHz continuous wave microwaves to determine the effect on temperature regulation. Exposure began 60 minutes after anesthetizing to allow for temperature stabilization. The tympanic, rectal, inguinal, axillary, back, hind toe and fore toe regions were monitored. Mean slopes of temperature curves for sham exposures (anesthetized, but not irradiated) did not become less negative by more than 0.36°C/hr. The change in mean slope for exposed animals appeared to be determined by size. Reduction of cooling rate was 1.5°C/hr for an 8.8 kg dog, 0.54°C/hr for a 12.6 kg dog and 0.62°C/hr for the remaining dogs weighing 23.5±0.9 kg. Rectal temperature was highest of recorded body temperatures 90 minutes after anesthesia in eight of nine experiments. Fore and hind toes showed a sudden increase in rate of cooling not apparent in other temperature curves during 6 of 9 experiments. Except for back, hind and fore toes, temperature differed in other locations on the same animal from between 0.5-2.9°C. Results show that animals remained homeothermic. Body heat regulation occurred through cooling of the extremities, aided by altered blood flow and was not dependent on microwave exposure. High rectal temperatures imply conduction and convection of heat from body core to skin or head. Convection to head is slowed or reversed during exposure. This study indicates significant changes in temperature gradients occur in anesthetized animals with or without head exposure to microwaves. (5 refs.)

4524 POTENTIAL MICROWAVE INJURIES IN CLINICAL MEDICINE. (Eng.) McRee, D. I. (National Inst. Environmental Health Sciences, Research Triangle Park, NC 27709). *Annu. Rev. Med.* 27: 109-115; 1976.

The use of microwaves in clinical medicine may be harmful, and their use requires precaution and an understanding of the potential danger. Microwaves have the valuable capability of penetrating biological materials to produce deep heating. The eyes and testes, however, are highly susceptible to damage by microwave exposure, since they have a limited blood flow for removal of heat. Exposure has been shown to cause cataracts in rabbits at 2450 MHz with a threshold at 150 mW/cm^2 for 100 minutes or for 10 minutes at 500 mW/cm^2. The eyes, therefore, should be shielded from exposure during diathermic treatment in the head region. The temperature sensitivity of testes has been demonstrated in one experiment in which Sprague-Dawley rats suffered testicular degeneration after 10 minutes of microwave exposure at 35°C and 2450 MHz. Effects on the central nervous system include headaches, increased fatiguability and irritability, sweating, difficulties in concentration and memory, and emotional instability. Other hazards include incorrect use of microwave blood-warmers, which may result in hemolysis, and possible electromagnetic interference with medical electronics, especially cardiac pacemakers. Proper administration techniques, therefore, should be used by trained personnel, with care taken to expose only the portion of the body being treated with adequate protection of the operator and those in surrounding areas. (27 refs.)

4525 THE PRACTICE OF MICROWAVE RADIATION SAFETY (SYMPOSIUM SUMMARY). (Eng.) Rexford-Welch, S. C. (RAF Consultant in Radiobiology, AWRE Aldermaston, Near Reading, Berkshire, U.K.); Lindsay, I. R. *J. Microwave Power* 11(2): 160-162; 1976.

The safety regimen adopted by major users of microwave radiation generally includes safety officer appointments, the production of safety instructions, area control, and classification and medical surveillance of workers, and incident investigation. Appointment of a safety officer for non-ionizing radiation requires no certified level of competency. This reflects the need for training stated by the World Health Organization. Safety orders are produced by major users without the spur of legislation and the guidance of codes of practice. The need for exposure standards for frequencies outside the microwave range, particularly 1-30 MHz, has to be recognised. Restricted areas are based on the microwave radiation personnel exposure standard (MPE) with only authorized entry during operation and hazard areas with no entry during operation. Also, it is imperative to reassess areas after equipment modification, new installation, and following an incident. Health surveillance should prevent the employment of persons who could be adversely affected by microwave radiation exposure. The classification of microwave radiation workers, based on the MPE of 10 mW/cm^2 and with required medical surveillance, is proposed, and the voluntary participation of associated workers in epidemiologic studies of exposures below this MPE is urged. Any untoward occurrance in a controlled area should be investigated as soon as possible, and preferably by a specialized team. This will include early technical assessment of the operating conditions and medical examination of exposed workers. Finally, the definition of a permissible exposure

level is paramount to any protection program, since it is not easy for the practitioner of microwave radiation safety to work with the divergence in recommended standards. (No refs.)

4526 THERMOSTABILITY OF THE ERYTHROCYTES OF MICE EXPOSED TO THE ACTION OF A MAGNETIC FIELD. (Eng.) Sebestik, V. (Inst. Hematology, Blood Transfusion, 128 20 Prague 2, U nemocnice 1, Czechoslovakia); Petz, R. *Physiol. Bohemoslov.* 25(3): 241-244; 1976.

The effect of a magnetic field, formed by the poles of a rotating permanent magnet of 200 gauss induction, on the thermostability of mouse erythrocytes was discussed. Fifteen CBA-strain female mice, 23-25 weeks of age, were exposed for an average of 17 weeks to the magnetic field; 15 additional mice served as a control group. These groups were compared to six animals exposed to the magnetic field during gestation. Erythrocyte thermostability was determined for this group three months postpartum. Results indicated that the rate of heat hemolysis of erythrocytes was significantly higher in the test groups exposed to the magnetic field, especially at 5 and 10 minutes of heating ($p<0.01$). After five minutes of heating, hemolysis in the exposed group had a mean value of 8.11 ± 4.36, while the mean of the group exposed *in utero* was 14.33 ± 6.24. The control group had a mean value of 3.76 ± 1.67. At 45 minutes, the differences between all groups were not significant. These results indicate that the effect of the magnetic field on the embryonic organism persists long after (three months) removal of the field. The decrease in the thermostability of the erythrocytes was associated with a decrease in their osmotic resistance, which was probably a direct result of the magnetic field on the erythrocyte cell membrane. (9 refs.)

4527 SCATTERING OF MICROWAVES BY DIELECTRIC MATERIALS USED IN LABORATORY ANIMAL RESTRAINERS. (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202); Wu, C-L. *IEEE Trans. Microwave Theory Techniques* 24(4): 219-223; 1976.

In most experimental investigations of the biological effects of microwave radiation, it is necessary to use low-loss dielectric materials for restraining animals under irradiation. Because of the complexity of the analysis of the animal-restrainer combination, an analysis was made of the scattering of microwave fields by a simplified model of the restrainer with no animal present. The model chosen was that of a plane wave incident at an arbitrary angle upon a rectangular slab of finite width and thickness. Numerical results indicated that the scattered fields within a square region of one wavelength in distance from the slab surfaces are greatly enhanced and highly nonuniform. In particular, the maxima for parallel incidence exceeded those for normal incidence by almost a factor of 2. The results suggested that for minimal perturbation the broad face of an animal holder should be oriented toward the direction of propagation. Further, the individual members of the restraining device should be as thin as practicable, and the dielectric materials should correspond to the characteristics of free space. (5 refs.)

4528 EFFECTS OF MICROWAVE-INDUCED LOCAL HYPERTHERMIA ON MAMMARY ADENOCARCINOMA IN C3H MICE. (Eng.) Mendecki, J. (Dept. Radiotherapy, Montefiore Hosp. and Medical Center, 111 East 210th St., Bronx, NY 10467); Friedenthal, E.; Botstein, C. *Cancer Res.* 36(6): 2113-2114; 1976.

Microwave-induced hyperthermia, produced by a 10 W microwave generator at a radiation frequency of 2450 MHz, was focused locally upon mammary adenocarcinoma implanted in C3H mice when the tumor reached 6 mm in diameter. In 54 treated mice, all tumors diminished in size after the first exposure (43°, 45 minutes) and disappeared completely following the second treatment. No other effects from heat application were apparent. All the mice in the microwave-treated group survived the whole period of observation (4 months) without any evidence of tumor, while 18 nontreated controls died within 4 weeks after inoculation. (9 refs.)

4529 NON-PERTURBING MICROPROBES FOR MEASUREMENT IN ELECTROMAGNETIC FIELDS (SYMPOSIUM SUMMARY). (Eng.) Deficis, A. (O.N.E.R.A.-C.E.R.T., Laboratoire du D.E.R.M.O., 2 Avenue Edouard Belin, B.P. 40-25, 31055 Toulousse Cedex France); Priou, A. *J. Microwave Power* 11(2): 148-149; 1976.

The possibility of obtaining a dielectric microprobe that would not interfere with electromagnetic waves has been studied. Two types of probes were defined: one operating in the temperature range of 10°C to 40°C, another within the range -40°C to +20°C. Both probes included a head (different according to the temperature range or density to be measured) but comprising a thermosensitive dielectric material, dielectric light conductors (optical fibers), and associated electronics. The first probe, (a "cholesteric crystal and optical fibers dielectric probe"), had a head composed of an optical transducer, a thermal sensor made of micro-encapsulated cholesteric liquid crystals, and coating absorbing waves formed by a thin film of colloidal graphite. In this system only two optical fibers were used: one bringing in the light, the other collecting the reflected light containing information on the temperature or power density variations. The second probe was a dielectric thermometer operating within a range of -30°C to +10°C. The principle of the probe was based on the reflection of a light beam on a thermodilatable liquid, contained in a capillary glass pipe of small dimension. The electronics was similar for both probes. A white light source powered the optical fiber(s). The reflected light was collected by a photomultiplier driven by a power supply. The analysis of the reflected light was then made either by recording on a plotter or by any other process. (No refs.)

4530 FAILURE OF 2- AND 10-METER RADIO WAVES TO INDUCE GENETIC DAMAGE IN *DROSOPHILA MELANOGASTER*. (Eng.) Mittler, S. (Dept. Biological Sciences, Northern Illinois Univ., DeKalb, IL 60115). *Environ. Res.* 11(3): 326-330; 1976.

Adult male *Drosophila melanogaster*, exposed to non-thermal radio waves, were studied to assess whether radio waves used for transmissional purposes pose a mutational hazard. *Drosophila*, in vials, were attached to two antenna and exposed for 12 hours to the frequencies of 136.34 and 29.00 MHz, respectively. The progeny of the exposed *Drosophila* were tested for sex-linked recessive lethals, loss of X or Y chromosomes, and non-disjunction. There was no significant difference between offspring of the control and exposed flies with respect to the genetic mutations. Spermatogenesis also was unaffected. It is concluded that the average portable transmitter does not pose a threat to the genetic integrity of its operator, since the frequencies tested are in the radio wave band regions used by police, emergency vehicles, radio amateurs, and civilian radio operators. (13 refs.)

4531 DETERMINATION OF POWER ABSORPTION IN MAN EXPOSED TO HIGH FREQUENCY ELECTROMAGNETIC FIELDS BY THERMOGRAPHIC MEASUREMENTS ON SCALE MODELS. (Eng.) Guy, A. W. (Bioelectromagnetics Research Lab., Sch. Medicine, Univ. Washington, Seattle, WA 98195); Webb, M. D.; Sorensen, C. C. *IEEE Trans. Biomed. Eng.* 23(5): 361-371; 1976.

A technique is described in which thermographically determined power absorption measurements in scale phantom models of man exposed to very high frequency fields are used to obtain power absorption characteristics in full scale man exposed to high frequency fields. When the body of man, small compared to a wavelength, is exposed to high frequency electromagnetic fields, the absorbed power density patterns and total absorbed power may be approximated by the simple super-position of the internal electric fields obtained from the quasistatic coupling characteristics of the electric and magnetic field components determined independently. A VHF resonant cavity was used to provide the necessary field strengths for producing measurable power absorption patterns under simulated HF exposure conditions. Results indicated that peak power absorption densities as high as 5.63 W/kg could be produced in man exposed to 10 mW/cm^2, 31 MHz radiation fields. The results show that the absorption decreased as the square of the frequency, as predicated by theory for frequencies below 31 MHz. (8 refs.)

4532 ELECTROMAGNETIC FORCES AND CIRCADIAN RHYTHMS (LETTER TO EDITOR). (Eng.) Hopewood, P. S. (Univ. Vermont, Coll. Medicine, Burlington, VT). *N. Engl. J. Med.* 294(9): 501-502; 1976.

It is questioned whether a procedure, electromagnetic bougienage, (Hendron and Hale, *New England Journal Medicine* 293:428, 1975), will interfere with a newborn's ability to perceive geophysical stimuli, thus changing diurnal rhythms, necessary hormonal responses, and subsequent growth development. This concern is based on the belief that man's circadian rhythm is cued by a geophysical sensor, which interprets information from magnetic fields, cosmic radiation, and gravity. Evidence indicates that planaria and mud snails will change direction with a change in magnetic field. In addition, electric fields have been used to shorten man's diurnal rhythm. If geophysical phenomena can be registered, then perhaps this information can be used by the central nervous system to alter bioelectric activity and diurnal rhythms. (7 refs.)

4533 ELECTROMAGNETIC PULSE INTERACTION WITH MAMMALIAN CRANIAL STRUCTURES. (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202). *IEEE Trans. Biomed. Eng.* 23(1): 61-65; 1976.

The transmitted field strengths in homogeneous spherical models of human and animal heads were determined to be a function of time and position, using frequency analytic techniques for an impinging pulse of Gaussian character. A Debye relaxation model and constant conductivity model were considered for the electrical behavior of brain matter. The constant conductivity model was used to predict continued decreases in pulse amplitude as it advanced in the head starting from the leading surface; however, the relaxation model predicted reduction only from the surface to the center. Moreover, it appears that the transmitted pulse in a spherical model of the head was always related to the time derivative of the incident radiation. Numerical results indicate that the transmitted pulse amplitude is quite small and can be estimated using the constant conductivity model. (13 refs.)

4534 PAIN SENSATIONS ASSOCIATED WITH ELECTROCUTANEOUS STIMULATION. (Eng.) Mason, J. L. (Dept. Electrical Engineering, University of Canterbury, Christchurch, New Zealand); Mackay, N. A. M. *IEEE Trans. Biomed. Eng.* 23(5): 405-409; 1976.

The results of experiments to determine the feasibility of using electrocutaneous stimulation in sensory substitution systems are discussed. The system may provide some facility for sound localization to the totally deaf by directing auditory information to an alternate sense. One of the main drawbacks to the development of this system has been the sharp, pricking pain often associated with electrocutaneous stimulation. This has been found to be a result of thermal damage to the corneal layer of the skin. The high-energy densities required to create this damage often occur, even at moderate stimulation currents, because of the highly nonhomogeneous nature of the skin-electrode interface. However, this pain can be controlled without resorting to electrode pastes by adopting a simple procedure for applying the electrode. The dynamic range and the stability of the sensation magnitude have been measured under paste-free conditions, and

the conclusion was reached that electrocutaneous stimulation would be a viable alternative to mechanical stimulation in certain sensory substitution applications. (9 refs.)

4535 ELF COUPLING TO SPHERICAL MODELS OF MAN AND ANIMALS. (Eng.) Spiegel, R. J. (IIT Res. Inst., Washington, DC 20006). *IEEE Trans. Biomed. Eng.* 23(5): 387-391; 1976.

The induced fields, currents, and power absorbed by spherical models of humans or animals when exposed to extremely low frequency (ELF) electromagnetic fields were calculated. Spherical models can be expected to provide values of the right order of magnitude. The induced fields were a sum of the quasistatic solutions for a sphere irradiated by a uniform electric and magnetic field. Calculations were provided for ELF fields emanating from the proposed Navy's Sanguine antenna and extra high voltage (EHV)/ultra high voltage (UHV) transmission lines proposed by the utility industry. Converting the predicted absorbed power into the average heat produced in a 70-kg man by the ELF field was found too be approximately 10^{-5} cal/gs. This induced heat production is considered too low to interfere with normal biologic function; however, this should be verified. (16 refs.)

4536 ARE MOUSE FETUSES WHICH SURVIVE MICROWAVE RADIATION PERMANENTLY AFFECTED THEREBY? (Eng.) Rugh, R. (U.S. Dept. Health, Education and Welfare, Public Health Service, Food and Drug Admin., Bureau of Radiological Health, 5600 Fishers Lane, Rockville, MD 20852). *Health Phys.* 31(1): 33-39; 1976.

Time-mated CFI white mice (118) were exposed when their fetuses were at 9, 12, or 16 days gestation to 7.4 W forward power of 2450 MHz microwave radiation for 4 minutes--a sub-lethal exposure. Mean absorptions of energy ranged from 22.4 to 27.1 J/g and were inversely proportional to weight and gestation age. After a normal delivery, these fetally irradiated mice were again exposed to the same irradiation as previously, from two months of age until death. Death was electronically monitored on a polygraph. A parallel group of 25 two-month-old controls were similarly irradiated, and the absorbed dose in J/g and the time in min to kill were taken as the measure of radiation tolerance or radiosensitivity of the originally irradiated fetuses. Males initially exposed to microwave energies at 12 and 16 days gestation, and females irradiated at 16 days gestation showed a slight but statistically significant reduction in the mean time to kill. Only the 12 day males showed a significant reduction in the mean absorbed dose at death. None showed mean absorbed doses greater than did the controls; hence, there was no evidence of any acquired resistance to radiation effects. All males initially exposed *in utero* had mean body weights significantly lower than did the control males at two months of age. Females initially irradiated at 16 days gestation were, at two months, statistically lighter in mean body weight than any of the other irradiated or control females. There was no significant difference between the sexes in J/g absorbed dose to kill at two months of age, but there was a significant lowering of the time to death for those males previously irradiated at 12 and 16 days gestation age and females at 16 gestation days compared with their respective controls. (13 refs.)

4537 INFLUENCE OF 2450 MHz CW MICROWAVES ON RATS EXPOSED *IN UTERO* (SYMPOSIUM SUMMARY). (Eng.) Michaelson, S. M. (Dept. Radiation Biology and Biophysics, Univ. Rochester, Sch. Medicine and Dentistry, Rochester, NY 14642); Guillet, R.; Catallo, M. A.; Small, J.; Inamine, G.; Heggeness, F. W. *J. Microwave Power* 11(2): 165-166; 1976.

Rats exposed *in utero* to 2450 MHz continuous wave microwaves were examined for indices of maturational deficits. Long-Evans rats at 9 and 16 days of gestation were exposed to 2450 MHz continuous wave microwave radiation at 10 mW/cm^2 or 40 mW/cm^2 for 1 hour. These exposures did not seem to adversely affect the rat or her offspring; parturition was normal with no change in gestation duration, and there was no difference in litter size (10-16 pups) from exposed and sham-irradiated dams. Oxygen consumption in cold stressed neonates from the 40 mW/cm^2 exposed dams was increased (about 75 ml O_2/min/kg) relative to controls and 10 mW/cm^2 exposures (about 50 ml O_2/min/kg and 43 ml O_2/min/kg respectively). Preliminary results suggest that corticosterone and thyroxine levels were comparable in all neonates examined. Corticosterone levels in the first 24 hours of life ranged from 10-25 µg% then dropped and remained at <2µg% through the 14th day. Plasma thyroxine (T4) levels in the neonatal rat were low (<3µg%) for the first 10 days of life in pups from both exposed and non-exposed dams. At days 11-12 a rise in plasma T4 levels to 4-8 µg% (normal adult levels) was seen in both groups. (No refs.)

4538 TEMPERATURE CHANGES GENERATED BY MICROWAVE THERAPY IN THE THIGHS OF HUMAN SUBJECTS (SYMPOSIUM SUMMARY). (Eng.) Stevens, A. (Dept. Physical Medicine and Electromyography, Univ. Leuven, Faculty of Medicine, B-3000 Leuven, Belgium); Peluso, F. *J. Microwave Power* 11(2): 170-171; 1976.

Deep tissue temperature elevations generated after exposures to microwave therapy were studied in human subjects. The right antero-lateral thigh of 20 male subjects of around 25 years of age were exposed to microwave radiation at 2450 MHz. A power output of 50 W was applied at a 10 cm distance from the skin surface for 10 minutes. Tissue temperatures were measured immediately after exposure, and 5, 10, and 15 minutes thereafter at six depths, i.e., at the skin surface, 2, 6, 11, 16 and 21 mm beneath it. Temperature elevation decreased with depth. Immediately after exposure very modest temperature elevations in the various tissue layers were found, i.e., from 2.5°C ± 0.6 on the surface to 1.0°C ± 0.3 at 21 mm underneath. The temperature changes in

muscle were smaller, i.e., from 1.9°C at 11 mm depth to 1.0°C at 21 mm. Fifteen minutes after the end of the radiation, the temperature elevations in the muscle and at the fat-muscle interface were still significant. This after-exposure heating effect suggests that only small changes in blood flow occur and that other mechanisms may have to be invoked to explain the therapeutic success obtained with this type of therapy. (No refs.)

4539 MICROWAVE RADIATION AND OTHER HARMFUL FACTORS OF WORKING ENVIRONMENT IN RADIOLOCATION: METHOD OF DETERMINATION OF MICROWAVE EFFECTS (SYMPOSIUM SUMMARY). (Eng.) Siekierzynski, M. (Postgraduate Medical Center, Military Medical Acad., ul. Szaserow 128, Warszawa, 60, Poland); Czarnecki, C.; Dziuk, E.; Jedrzejczak, W. W.; Szady, J. *J. Microwave Power* 11(2): 144-145; 1976.

This analysis included 841 males with occupational exposure to pulse-modulated microwave radiation. The subjects were divided into two groups: Group I consisted of 507 subjects exposed to energy beam densities exceeding 2 W/m^2 (sometimes exceeding 60 W/m^2), and Group II consisted of 334 subjects exposed to energy beam densities never exceeding 2 W/m^2. The incidence of functional disturbances, gastric and duodenal ulcer, the functional state of the thyroid, lens transparency, causes of disability to work, consequences of excessive accidental radiation exposure, and changes in the abnormalities after cessation of exposure to radiation were determined. No differences were observed in the health state between groups differing only in the degrees of exposure to microwave radiation. It was found that the incidence of many abnormalities was influenced by increasing age of the subjects and not by the duration of work connected with exposure. This observation does not support the hypothesis of cumulative effects of microwave exposure with increasing length of work under conditions of exposure. The presence of various functional disturbances in nearly 60% of the subjects in both compared groups indicated a highly neurotizing influence of the whole complex of environmental factors other than microwave radiation. (No refs.)

4540 AN UPPER BOUND ON COEFFICIENT OF TRANSMISSION OF MICROWAVE LEAKAGE INTO BIOLOGICAL TISSUES (SYMPOSIUM SUMMARY). (Eng.) Kamal, A. A. (Dept. Electronics and Communications, Faculty of Engineering, Cairo University, Giza, Cairo, Egypt); Al-Badwaihy, K.; Hashish, E. *J. Microwave Power* 11(2): 159-160; 1976.

An attempt to find an upper bound on the transmission coefficient U for various near zone fields was undertaken. A planar model consisting of a half space of homogenous biological tissues with known electromagnetic properties (permittivity, conductivity and permeability) was used in the study. The source was an elementary electric or magnetic dipole located in the free space region above the biological half space. The incident field was decomposed into a continuous spectrum of cylindrical waves. For each component wave the transmitted field was found, and an integration gave the value of total transmitted field into the biological material. It is concluded that as the height of the dipole decreases, the maximum of the transmission coefficient U shifts towards the dipole projection. Also, its value increases, and for low values of the dipole heights, the maximum value of transmission exceeds that based on a plane wave assumption. (No refs.)

4541 VARIATION OF SERUM TRIGLYCERIDES RATE UNDER THE ACTION OF ELECTROMAGNETIC WAVES: POWER LEVEL INFLUENCE (SYMPOSIUM SUMMARY). (Eng.) Deficis, A. (Centre d'Etudes et de Recherches de Toulouse, Toulouse, France); Dumas, J. C.; Laurens, S.; Plurien, G. *J. Microwave Power* 11(2): 136-137; 1976.

The effect of electromagnetic field exposures on the liquid metabolism of mice was investigated. Groups of 12 mice (Swiss origin, male) were exposed for nine days (15 hours/day) to electromagnetic fields of 2.4 GHz at power densities ranging from 1-3.3 mW/cm^2. Three microwave power levels were applied to the animals. In the lowest case (1 mW/cm^2), the triglyceride rate was the same in every animal. However, at both other power levels (1.5 and 3.3 mW/cm^2), a significant increase in the triglyceride rate was observed in the exposed animals. In a second experiment, the triglyceride rate for animals exposed to electromagnetic radiation was compared to that of animals exposed to infrared radiation. At 1.5 mW/cm^2, the triglyceride rate was the same for every animal. However, this rate was significantly higher in animals that were exposed for nine days to microwaves at 3.3 mW/cm^2 than in animals that were exposed for the same period and at the same power level to infrared radiation. The results suggested the possibility that microwaves act on the lipid metabolism through an internal mechanism, which is noticeable only over a certain exposure level. (No refs.)

4542 RETINAL SENSITIVITY TO SHORT WAVELENGTH LIGHT (LETTER TO EDITOR). (Eng.) Marshall, J. (Inst. Ophthalmology, Judd St., London WC1H 9QS, U.K.); Weale, R. A. *Nature* 262: 629; 1976.

Conclusions in a recent article in *Nature* on potential hazards due to exposure of the primate retina to visible radiation of short wavelengths are questioned. The lesions were thought to be mediated by a photochemical mechanism; however, the reciprocity law was not obeyed in the data of the article, although both human rods and cones obey the law in the author's timespan. Thermal effects were minimized, even though the action spectrum resembled the absorption spectrum of melanin. The role of the crystalline lens as protection for the retina was emphasized, although the vitreous may be at risk in aphakic eyes. The morphology of the lesion was ignored. The authors also implied that viewing the sun under their experimental conditions, below the threshold for lesions of 100/sec, is safe. It should

not be inferred, however, that a shorter period is safe in their experimental conditions. (6 refs.)

4543 RETINAL SENSITIVITY TO SHORT WAVELENGTH LIGHT--AUTHOR'S REPLY (LETTER TO EDITOR). (Eng.) Ham, W. T. (Dept. Biophysics, Medical Coll. Virginia). *Nature* 262: 629-630; 1976.

There are at least three types of radiation damage to the retinal in the range (1,400-400nm). These are shock damage, thermal damage, and photochemical damage. Marshall's report appeared to belong in the thermal damage category. In response to the letter from Marshall and Weale, not even thermal lesions obey a reciprocity law, and the authors do not know the relationship of rods and cones to the observed funduscopic pathology. Thermal effects were minimized only for long term exposure to the shorter wavelengths in the visible spectrum where maximum temperatures in the retina do not exceed a few °C above ambient. The absorption spectrum of melanin would be expected to correspond to the action spectrum for thermal damage. Hazard to the retina rather than to the vitreous for aphakic eyes was emphasized because the vitreous does not absorb radiation appreciably between 300 and 1,400 nm. The morphology of the lesion was undetermined; however, light and electron microscopy are currently being used to determine the nature of the lesion. Calculations showed that the minimal irradiance on the retina in Marshall's experiments were greater by a factor of 10^3 than those reported by the author. Marshall, then, was dealing with the phenomenon of thermal injury; whereas, the author sought to characterize a long term photic damage mechanism or mechanisms in the retina. (9 refs.)

4544 RATE EFFECTS IN ISOLATED TURTLE HEARTS INDUCED BY MICROWAVE IRRADIATION. (Eng.) Tinney, C. E. (Biosystems Dept., Naval Undersea Center, San Diego CA); Lords, J. L.; Durney, C. H. *IEEE Trans. Microwave Theory Techniques* 24(1): 18-24; 1976.

It is known that continuous wave microwave irradiation at 960 MHz causes bradycardia in isolated poikilothermic (turtle) hearts in Ringer's solution. Tachycardia is usually produced by generalized heating, suggesting the possibility of a different mechanism in this case. The effect occurs only over a narrow power range of approximately 2-10 mW/g absorbed by the heart. In this study, the hypothesis that microwave radiation causes neurotransmitter release either by excitation of the nerve remnants in the heart or by some other mechanism, producing bradycardia over a restricted range of power absorption, was investigated. Approximately 8 mW/cm^3 continuous wave microwave radiation at 960 MHz was applied to groups of isolated turtle hearts for a period of 1/2 hour in the presence of a parasympathetic nerve blocking agent (atropine) and in the presence of a sympathetic nerve blocking agent (β blocker), alone and in combination. In the presence of atropine, the heart rate increased, while in the presence of β blocker, the heart rate decreased. When both atropine and β blocker were added in combination to the heart preparation, the effects of both the sympathetic and parasympathetic transmitter were blocked. Microwave irradiation then caused only very slight changes in heart rate. A generalized heating effect, causing tachycardia, was predominant at higher levels of absorbed power (above approximately 15 mW/cm^3). It is concluded that the neural effect (possible transmitter release due to microwave irradiation) is dominant at lower power levels, although the exact location of the stimulation causing the observed effects has not yet been determined. (5 refs.)

4545 A PASSIVE ELECTRODELESS METHOD FOR DETERMINING THE INTERIOR FIELD OF BIOLOGICAL MATERIALS. (Eng.) Brodwin, M. E. (Dept. Electrical Engineering, Northwestern Univ., Evanston, IL 60201); Taflove, A.; Matz, J. E. *IEEE Trans. Microwave Theory Techniques* 24(8): 514-521; 1976.

A passive remote-sensing method was developed for the measurement of the electric-field distribution within a biological sample. The instrument was used to analyze the intermodulation spectrum reradiated by a diode imbedded within the sample exposed to a dual-frequency illumination. Experimental results in a waveguide system indicated that the relative intensities of the intermodulation products were a unique function of the field intensity at the diode. These results were also used to determine the basic scattering properties of the diode. A low-power free-space apparatus is described which was used to expose the principal problem associated with this method: the inadvertent generation of intermodulation frequencies. Isolation techniques eliminated this problem. Finally, an analysis of a complete system revealed that at 910 MHz, fields could be measured in 4.0 cm of soft tissue, tan $\sigma = 0.5$, without exceeding an incident power density of 10 mW/cm^2. (6 refs.)

4546 MATERIALS FOR SELECTIVE TISSUE HEATING IN A RADIOFREQUENCY ELECTROMAGNETIC FIELD FOR THE COMBINED CHEMOTHERMAL TREATMENT OF BRAIN TUMORS. (Eng.) Moidel, R. A. (Dept. Neurosurgery, Univ. Pittsburgh, Pittsburgh, PA 15213); Wolfson, S. K., Jr.; Selker, R. G.; Weiner, S. B. *J. Biomed. Mater. Res.* 10(3): 327-334; 1976.

A technique of creating localized heating by implanting carbon steel rods and Hysterloy (1000 and 655 calorimetry/g-min, respectively) in the brain of a squirrel monkey and inserting the head into a radiofrequency electromagnetic field is described. Heating of these materials was done primarily by eddy current (37 kHz), since their heating rates were significantly affected by their shapes and orientation in the field; the rods oriented parallel to the field produced the most heat. This preliminary experiment shows that carbon steel and Hysterloy were successful in producing localized heating in live squirrel monkey brains. (8 refs.)

4547 EFFECTS OF THE SURROUNDINGS ON ELECTROMAGNETIC-POWER ABSORPTION IN LAYERED-TISSUE MEDIA. (Eng.) Bernardi, P. (Inst. of Electronics, Univ. Rome, Rome, Italy); Giannini, F.; Sorrentino, R. *IEEE Trans. Microwave Theory Techniques* 24(9): 621-625; 1976.

A model for studying the interaction between electromagnetic (EM) waves and biological tissue is introduced. The influence of the surroundings, the thickness of the irradiated tissue, and of the disuniformity of the incident field was examined by schematizing the environment by a perfectly conducting screen placed beyond the irradiated tissue. The effects of standing waves, which were created in this situation, were determined as a function of the electrical and geometrical parameters of the structure. In particular, the hazard increase due to the presence of the screen combined with a phase disuniformity of the incident field--an elementary schematization of the "near-field"--was pointed out. (13 refs.)

4548 DIFFERENTIAL EFFECTS OF ELECTROMAGNETIC FIELDS IN THE TREATMENT OF NEUROSES AND DEPRESSION. (Eng.) Grunner, O. (Res. Centre Inst. Balncology, Lazne Pesenik, Czechoslovakia). *Act. Nerv. Super.* 17(4): 294; 1975.

The effects of the cerebral application of electronic broad-band noise (EBBN) (1 = 20 mA) to 20 patients with neurotic and depressive disorders were com - pared. Electric skin resistance (ESR) increased after treatment by more than 1/3; whereas, it decreased in patients treated with a "placebo." This indicates a significant inhibitory effect. Some neurotics complained of dizziness and hightened irritability, while others stressed hightened phychic activity during treatment. Patients with depression, treated similarly, indicated no side effects. An EBBN of lower intensity (1-2 mA) or squared pulse-current (0.8-1.2 mA) was suitable for treatment of anxious neurotics. Application of a continuous direct magnetic field (CDMF) for one hour on anxious neurotics with insomnia and hightened irritability exercised a significant inhibitory effect (increase in ESR). Repeated (CDMF) applications, 9 times in 3 weeks, on 12 anxious neurotics with insomnia confirmed this finding. It is suggested that the effectiveness of the treatment depends on the type and intensity of the electric current and magnetic field. (3 refs.)

4549 MICROWAVE-INDUCED HYPERTHERMIA AS AN ADJUVANT TO CANCER THERAPY (SYMPOSIUM SUMMARY). (Eng.) Wallen, C. A. (Dept. Radiation Biology and Biophysics, Univ. Rochester, Sch. Medicine and Dentistry, Rochester, NY 14642); Michaelson, S. M. *J. Microwave Power* 11(2): 175-176; 1976.

A review of the application of microwave-induced hyperthermia as an adjuvant to ionizing radiation and chemotherapy in cancer treatment is presented. The effects of hyperthermia and the temperature levels, which must be maintained, are also discussed. Therapeutically effective hyperthermia must raise the intratumor temperature to approximately 42°C with an operational range in animals and man of 41.5°C to 42°C. Higher temperatures have been found to give more rapid tumor destruction. However, host tolerance considerations, contraindicate the use of temperatures exceeding 42°C, which should be maintained for a sufficient time to inactivate the aerobic and hypoxic tumor cells, while not damaging adjacent normal tissue. It also has been noted that non-uniform heating enhances growth and metastasis of a tumor. Microwave-induced hyperthermia may provide unique possibilities for minimizing the problem of non-uniform heat distribution in the tumor. The thermal effects of high intensity microwave absorption in biological tissue is well established. The allowed frequencies for diathermy are 27.12, 915, and 2450 MHz in the United States and 433 MHz in Europe. In contrast to infrared and surface heating, the relatively long wavelengths of microwave radiation permit the energy to penetrate deeper into biological tissue. Therefore, a more rapid and uniform generation of heat is possible using this modality. Hyperthermia has been shown to interact with radiotherapy and chemotherapy synergistically. This synergistic combination could lead to improved cures since lower levels of both modalities could be used. (10 refs.)

4550 MICROWAVE HEATING OF MALIGNANT MOUSE TUMORS AND TISSUE EQUIVALENT PHANTOM SYSTEMS. (Eng.) Robinson, J. E. (Div. Radiation Therapy, Dept. Radiology, Univ. Maryland, Sch. Medicine, Baltimore, MD 21201); McCulloch, D.; Edelsack, E. A. *J. Microwave Power* 11(2): 87-98; 1976.

This study investigated the use of microwaves to produce stable and reproducible temperatures (44°± 25°) in malignant mammary mouse tumors (1 cm in diameter) and tissue equivalent phantom systems. A 200 watt pulse mode, 2450 MHz diathermy machine was the microwave source. Initial tumor temperatures were well below body temperature, between 28°C and 31°C. Phantom tumors showed a notable increase in heat compared with mouse tumors. Heat variations may have been due to thermoregulation. Temperature profiles were obtained for tumors under four conditions: unheated, microwave heated, air heated, and microwave and air-heated. Similar size tumors were also compared under these conditions. Results indicated that both core temperature and thermal distribution depended appreciably upon ambient temperature. Microwave heating at room temperatures resulted in unacceptably high non-uniform profiles. This technique, which combined microwave and air-heating, decreased thermal nonuniformities, reduced microwave power requirements for elevated temperatures (up to 45°C) in tumor core, and allowed for reproducible tumor temperatures (within ± 1°C). However, this is still considered an excessive deviation. (6 refs.)

4551 USE OF AN INDUSTRIAL PROTOTYPE MACHINE FOR DRYING AND STERILIZING PHARMACEUTICAL AMPOULES BY MICROWAVES AT 2.45 GHz (SYMPOSIUM SUMMARY). (Eng.) Mothiron, J. C. (Establissement Rene Anrep,

Zone Industrielle du Menneton, 37000 Tours, France); Vialard-Goudou, A.; Maupas, P. *J. Microwave Power* 11(2): 200-201; 1976.

An experimental bacterial contamination of empty pharmaceutical ampoules, by different microbial strains, made it possible to test the sterilizing power obtained with an industrial prototype machine using microwaves at 2.45 GHz. Gram-positive and gram-negative bacteria in vegetative and sporulated forms were used to contaminate the washing water of ampoules treated subsequently with microwaves. With a period of four minutes and a power of 3 kW, drying was complete and sterilization satisfactory. Results indicated that with massive contamination the majority of ampoules were sterilized, although some ampoules still contained a few viable germs. There does not seem to be any significant difference in the sterilization of vegetative forms using microwave and between gram-positive and gram-negative bacteria. The influence of the germ concentration, at a given power, is a non-negligible parameter and leads to variable results depending on the bacterial species and more particularly with sporulated forms. It seems that sterilization is due only to the thermal effect obtained. The results of drying-sterilization with microwaves are favorable and make it possible to envisage industrial applications. (No refs.)

4552 INFLUENCE OF RADIO AND TELEVISION SETS ON IMPLANTED CARDIAC PACEMAKERS. (Ger.) Bisping, H.-J., Irnich, W. (Abteilung Innere Medizin I, Technische Hochschule, 5100 Aachen, Goethestr. 27-29, West Germany). *Dtsch. Med. Wochenschr.* 101(17): 669-672; 1976.

The possible interference by radiation emitted by television and radio sets and their accessories with implanted pacemakers with low threshold was investigated. The leakage fields generated by ultrasonic remote controls for television and radio sets, with a frequency of 30-65 kc/s, had too low an intensity to interfere with pacemaker function. Flexless infrared earphones, with an infrared emitter generating a carrier frequency of 100 kc/s installed in a television or radio set, also represented no danger for pacemaker patients. The interfering frequency emitted by the tuning oscillator of the television set during tuning was in the range of 85-900 Mc/s. Its intensity was too low to cause interference with pacemakers. It was concluded that pacemaker wearers may go near television and radio sets and use remote control accessories without any danger. (6 refs.)

4553 THE CONTINUING MEDICAL SURVEILLANCE OF PERSONNEL EXPOSED TO EXTREMELY LOW FREQUENCY (ELF) ELECTROMAGNETIC FIELDS. (Eng.) Houk, W. M. (Naval Aerospace Medical Res. Lab., Pensacola, FL). *Natl. Medical Res. Lab. Report No. 1225:* 17 pages; March 1976.

The medical surveillance (range 2-5 years) performed on a small group of personnel operating the extremely low frequency (ELF) communications test station in Clam Lake, Wisconsin is reported. In 1971, 24 age-sex pairs of control and exposed personnel entered this study, aimed at investigating the effects of ELF electromagnetic radiation on the health of personnel. In 1973, the seven individuals remaining in the surveillance program underwent physiochemical and psychometric testing. Physicochemical tests included: serum lipid, carbohydrates, blood alcohol, eye, audio, radiography, electroencephalograph (EEG), photic stimulation, glucose tolerance (GTT), electrocardiograph (EKG), triglycerides, and cholesterol. The results indicated little change in health status from 1971 in these seven volunteers. In 1974/75, five of six subjects had elevated GTTs. However, there was no evidence that exposure to the ELF electromagnetic field had any causal relation to this finding. Elevated GTT can be found in connection with lipid abnormalities, obesity, hypertension and heart disease. Except for one individual, all EKGs taken at rest were normal; EEGs, X-rays, and pap smears were all normal. Psychological testing indicated no apparent changes. With the limited number of subjects, it is difficult to determine the possible effects of ELF electromagnetic fields on the health of the general public. (9 refs.)

4554 POINT ELECTROANESTHESIA: REPORT III: GENERAL ELECTROPHARMACEUTICAL ANESTHESIA. (Eng.) Limoge, A. (Institut de Recherche d'Electroanesthesie, Faculte de Chirurgie-Dentaire, Paris V, 1, rue Maurice-Arnoux, 92120 Montrouge, France); Debras, C.; Louville, Y.; Atinault, A.; Lepresle, E.; Manne, J.; Degos, J. -D.; Boisgontier, M. -T. *U.S. Army Medical Research and Development Command Report* (ADAO 25075): pp. 13-55; February 1976.

This report presents the progress toward total elimination of drugs from anesthesia and the advance of pure electroanesthesia. The report includes a hemodynamic study on animals under electroanesthesia. Eight dogs (15 kg average weight), placed under electroanesthesia, had a stable and deep sleep followed by a rapid awakening. There appeared to be no difference between neuroleptanalgesia and electropharmaceutical anesthesia except for an increase in oxygen consumption during the initial wakening period. Human clinical studies are discussed with applications of electroanesthesia for thoracic, cardiac, and urological surgery. Electroanesthesia was found to be useful in high risk patients on whom it would be difficult to operate under narco-neuroleptanalgesia. Three types of tests were used to compare patients administered classical or electropharmaceutical anesthesia: modifications of neurological exams after anesthesia, quality of awakening following intervention, and the state of memory function. The study of psychological manifestations included testing for modifications of personality and memory. The results of these tests do not provide

a significant difference between classical and electroanesthesia before or after intervention. Further studies will be needed to establish conclusively that electroanalgesia does not cause any deterioration of intellectual functions, and that personality alterations are similar to those resulting from classical anesthesia. (No refs.)

4555 CHROMOSOME STUDIES OF RADAR CENTER STAFF EXPOSED TO ELECTROMAGNETIC RADIATION. (Ita.) Ciaccia, A.; Malacarne, P.; Piffanelli, P.; Della Piccola, A. (Direzione Sanita, 1ª R.A., Milan, Italy). *Minerva Med.* 67(24): 1557-1560; 1976.

Five subjects (ages 32-52) chronically exposed to electromagnetic radiation in radar centers (10, 17, 25 years) were studied for chromosomal alterations. Approximately 450 metaphases were analyzed in short-term cultures of peripheral blood for each subject, including five controls. Hypotonic shock was obtained with sodium citrate in two employees and two controls, and with potassium chloride in the others. Results showed chromatid alteratiosn, two presumed chromosomal alterations in exposed personnel, and five chromosome breaks in controls. There was no statistical difference between the two froups. There was a significant difference between the two hypotonic mediums in the exposed personnel with regard to chromatid and isochromatid alterations (2.05 and 2.17 respectively). (no refs.)

4556 ASSESSMENT OF THE EM FIELD COUPLING OF 915 MHz OVEN LEAKAGE TO HUMAN SUBJECTS BY THERMOGRAPHIC STUDIES ON PHANTOM MODELS (SYMPOSIUM SUMMARY). (Eng.) Webb, M. D. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington, Sch. Medicine, Seattle, WA 98195); Guy, A. W.; McDougall, J. A. *J. Microwave Power* 11(2): 162-164; 1976.

Full-sized human female (1.63 m tall; weight, 59 kg) and child (0.94 m tall; weight, 15 kg) phantom models with dielectric properties equivalent to those of muscle were exposed to electromagnetic leakage radiation from a microwave oven. A power amplifier, tuned to 919.5 MHz, was used. The models were exposed in three different positions. The female model was placed 5 cm, 10.1 cm, and 35.5 cm from the power amplifier. The exposure time was 300 sec for each position. The child model was placed at eye level 4.8 cm, 9.9 cm, and 35.3 cm from the power amplifier. The exposure time was 120 sec for all three positions. The regions of maximum specific absorption rates (SAR) were found to be those closest to the power amplifier; moderate levels of SAR were also observed in the neck region of the child. In all other regions of the models, the SAR was too low to be determined. The energy absorption distribution along the normal direction into the female model was similar to that predicted for a plane slab of the same material. The maximum SAR of 136 mW/kg per mW/cm^2 occurred at the surface and decreased exponentially with depth. The energy absorption pattern in the child's head showed the nasal region to have the maximum SAR of 455 mW/kg per mW/cm^2 at the surface. There was also significant absorption in the forehead, nose and mouth. For all of these regions, the maximum SAR occurred at the surface and decayed exponentially with depth. It is concluded that a power density leakage level of 5 mW/cm^2 should be expected to have negligible thermal significance in comparison to the metabolic rate of the human. (No refs.)

4557 STYROFOAM CAGES FOR RATS USED IN MICROWAVE RESEARCH: COATING WITH QUININE. (Eng.) Catravas, G. N. (Armed Forces Radiobiology Res. Inst., Bethesda, MD 20014). *Health Phys.* 31(1): 68-69; 1976.

The design for a quinine coated styrofoam cage for confinement of rats during exposure to electromagnetic radiation microwaves is discussed. Of all plastic materials used to construct cages for the confinement of rats during exposure to electromagnetic radiation only styrofoam has been found to be transparent to microwaves. Styrofoam sheets 0.5 inches thick were glued together with Elmers casein glue to make a cage of height 6 inches, width 6.5 inches and length 10 inches. Feces and urine were removed from the bottom of the cage by a series of parallel plexiglas tubes 0.375 inches outside diameter, 0.0625 inches wall thickness, and 0.25 inches apart to insure that waste materials would not perturb the electromagnetic field. One end of the tube was embedded in 1 inch thick styrofoam. Good ventillation was achieved by similiarly constructed covers. A 10% solution of quinine in absolute methanol was applied to the inner sides of the cage to determine whether this solution is effective in deterring rats from chewing their way out of the cage. Sprague-Dawley rats, 8-10 weeks old, were placed in coated and uncoated cages. Rats in coated cages remained in the cage for the duration of the experiment (24 hours), while rats in uncoated cages chewed their way out within 1-2 hours. Coated and uncoated cages were identical in terms of microwave transparency. (8 refs.)

4558 EXPERIMENTAL AND CLINICAL ASPECTS OF HYPERTHERMIA APPLIED TO THE TREATMENT OF CANCER WITH SPECIAL REFERENCE TO THE ROLE OF ULTRASONIC AND MICROWAVE HEATING. (Eng.) Har-Kedar, I. (Oncological Dept., Sheba Medical Center, Tel Hashomer, Israel); Bleehen, N. M. *Adv. Radiat. Biol.* 6: 229-266; 1976.

The role of hyperthermia alone, and in combination with radiation and chemotherapy in the treatment of cancer, is discussed, with special attention given to the use of microwaves and ultrasound. The follow-

ing mechanisms for the action of hyperthermia are considered. Tumor masses lack a good blood supply system, and therefore, are more sensitive to heat because heat dispersion is poor. Hyperthermia may act by inhibiting DNA synthesis in tumor cells. Autoradiographic studies indicate that above 39°C there is a drop in DNA synthesis. Large temperature differentials have been achieved by cooling the body to 30-32°C and heating the tumor to 42-43°C. Microwaves and ultrasound beams can be focused at deep seated tumors, and therefore, have potential for widespread clinical use. Further, it is suggested that cancer cells may be more vulnerable than normal cells to certain microwave range frequencies. Cancer cells may contain more bound water than normal cells, and microwave energy absorption has been shown to be greater at certain frequencies for bound water. The use of whole body heating and localized limb perfusion, however, is considered limited, and the theoretical advantages of microwaves over other methods of achieving hyperthermia remain to be demonstrated. (198 refs.)

4559 HEALTH HAZARDS FROM MICROWAVE EXPOSURE (LETTER TO EDITOR). (Eng.) Bush, D. (Univ. Radiation Protection Officer, Univ. Birmingham, Birmingham, B15 2TT, England). *Annu. Rev. Med.* 27: 431; 1976.

It is stressed that the maximum permissible levels of exposure to non-ionizing radiation in the United States may be too high. The maximum permissible level in the U.S.S.R. is 0.01 mW/cm^2, while it is 10 mW/cm^2 in the United States, and the United Kingdom. The U.S.A./U.K. standard is based on aberrations due to thermal effects, while the U.S.S.R. standard considers damage to the nervous system, inhibition of growth, and functional changes. These effects occur at a level well below the present U.S. standard. Due to the large increase in the use of microwave power sources, the author urges the International Radiation Protection Association to seek an international agreement on maximum permissible exposure levels to nonionizing radiation, especially microwaves. (14 refs.)

4560 PASSIVE TELEMETRY FOR IN VIVO MEASUREMENT OF FIELDS IN BIOLOGICAL MATERIALS (SYMPOSIUM SUMMARY). (Eng.) Brodin, M. E. (Northwestern Univ., Evanston, IL 60202). *J. Microwave Power* 11(2): 151-152; 1976.

A passive remote sensing method is described for the measurement of electric fields within biological samples. The intermodulation spectrum reradiated by an implanted diode was used to determine the field. The diode was exposed to dual frequency illumination and, because of inherent nonlinearity, the reradiated field contained intermodulation components. The power distribution among the intermodulation components was uniquely related to the field intensity at the diode, and by measuring the power of the components, the field was determined. The theoretical relation between the incident field and the reradiated intermodulation components was developed and applied to a biological sample. Microwave experiments are described, which verify the theory, and the results of a calculation for the expected observations in a biological sample are presented. Using these results and assuming soft tissue, it was demonstrated that for a material with a loss tangent of 0.5 and the diode implanted 4.0 cm from the surface, 24 dBw would be required for the observation. This corresponds to an input density of 10 mW/cm^2. Similar calculations were performed for 2450 MHz. (No refs.)

4561 SEARCH FOR CORRELATION BETWEEN GEOMAGNETIC DISTURBANCES AND MORTALITY. (Eng.) Lipa, B. J. (Inst. Plasma Res., Stanford Univ., Stanford, CA 94305); Sturrock, P. A.; Rogot, E. *Nature* 259: 302-304; 1976.

An attempt was made to correlate the daily number of deaths in the United States due to coronary heart disease and stroke from 1962-66, with different geomagnetic activity. Various Soviet studies have claimed a positive correlation exists between geomagnetic storms and the incidence of some human diseases. In this study, mortality rates were compared with corresponding Ap indices (world indices for geomagnetic activity) using three methods. Mortality data was normalized to remove weekly and seasonal variations and a long term secular trend. No evidence for correlation at the 3σ significance level was found. In an alternate procedure, superposed epoch diagrams were constructed for deaths on days with Ap in selected ranges. No diagram indicated a statistically significant association between daily deaths and magnetic index. The third method of presentation was to plot averaged deaths as a function of magnetic index for $-20 \leq k \leq 20$. These studies did not support the findings of Soviet studies, which claim a positive correlation exists between geomagnetic activity and disease. The Soviet results were either not statistically significant or not due to a causal relationship between geomagnetic disturbances and coronary heart disease and stroke. (10 refs.)

4562 ESTIMATION OF THE OCCURRENCE OF NEUROTIC DISORDERS IN SEA ECONOMY WORKERS EXPOSED TO THE ACTION OF ELECTROMAGNETIC WAVES. (Eng.) Dolmierski, R. (Inst. Maritime and Tropical Medicine, Gdynia, Poland); Nitka, J. *Bull. Inst. Marit. Trop. Med. Gdynia* 27(1): 57-61; 1976.

The incidence of neurosis in 12 persons exposed to electromagnetic waves is investigated. Of the 42, 18 were wireless operators, and 24 were employees of the Maritime Radio Service. Daily exposure had been four hours with length of exposure between 2-24 years. (12.5 average). They were administered the following tests: cuneostatic, orthostatic, Aschner 100, Aschner 150, hyperventilation, and time of maximum apnoea. Clinical examination showed 20 normal, 19 borderline, and 3 neurotic. This group was compared to groups of 40 normal and neurotic sailors. The test group did not differ from controls in orthostatic, hyperventilation, and time of maximum

apnoea tests. However, the cuneostatic tests were similar for wireless operators (-4.5) and neurotic sailors (-4.5). The Aschner 100 and Aschner 150 tests also showed a correlation between neurotic sailors and workers exposed to microwaves. Neurotic symptoms in more than 50% of the test group indicated an increased risk of neurosis for workers exposed to microwaves. These results demonstrate a need for periodic psychoneurologic examinations and exclusion of persons susceptible to neurosis from work with microwaves. (8 refs.)

4563 BIOMEDICAL EFFECTS OF MICROWAVE RADIATION--A REVIEW. (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202). *Natl. Electron. Conf. Proc.* 30: 224-232; 1975.

Research conducted in the Soviet Union, Eastern Europe, and the United States on the biologic effects of microwave radiation is reviewed. The clinical, hygienic and experimental studies from the Soviet Union and Eastern Europe indicate changes that occur in the nervous, cardiovascular, digestive, excretory, and hematopoietic systems due to microwave radiation. The main effect, however, is on the nervous and cardiovascular system, while other effects (i.e., lethargy) are secondary manifestations of generalized excitation of the central nervous system. These changes occurred in humans at low level exposures of 10 mW/cm^2 or less and were generally reversible. Recent United States investigations included studies on neural, behavioral, cataractogenic, testicular, and genetic effects. Rabbits exposed to near zone 2450 MHz for a minimum of 150 mW/cm^2 for 100 min developed lens opacity. However, under controlled hypothermia, rabbits similarly exposed did not produce lens opacities. Genetic studies showed only 24% of irradiated pupae of mealworm beetles exposed to 10 GHz continuous wave developed normally. Quail eggs exposed at 2450 MHz with an absorbed energy of 14 mW/gm showed no influence on cellular differentiation. The author stresses a need for studies on long term exposure effects, large scale epidemiologic investigations, and a better understanding of the mode of interaction between microwave radiation and biologic systems. (80 refs.)

4564 INTERACTION OF TWO CROSS-POLARIZED ELECTROMAGNETIC WAVES WITH MAMMALIAN CRANIAL STRUCTURES. (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202). *IEEE Trans. Biomed. Eng.* BME-23(5): 371-375; 1976.

The interaction of two cross-polarized plane electromagnetic waves with six-layered spherical models of a mammalian head was studied. The numerical results indicated that the absorbed powers induced inside small animal and human heads by incident circularly polarized waves and linearly polarized waves were very similar, except that the absorbed power in the planes transverse to the direction of propagation is uniform for the cross-polarized wave. It was also shown that the average absorbed power depended strongly on the frequency and head size involved. The maximum absorbed powers in a given size spherical head varied only slightly with frequency for the two frequencies studied. However, since a greater amount of the absorbed power occurs in the inner sphere representing the brain of a human head when 918 MHz rather than 2450 MHz is used, the former constitutes a greater health hazard to man at the same incident power. (13 refs.)

4565 STUDY OF THE EFFECTS OF CHRONIC LOW LEVEL MICROWAVE RADIATION ON RABBITS (SYMPOSIUM SUMMARY). (Eng.) Guy, A. W. (Sch. Medicine, Univ. Washington, Seattle, WA); Harris, C.; Kramer, P. O.; Emery, A. F. *J. Microwave Power* 11(2): 134-135; 1976.

A special exposure system was developed and used to chronically irradiate rabbits to a power density level of 10 mW/cm^2 for a period of six months. The system allowed a total of eight rabbits to be studied simultaneously--four receiving continuous 2450 MHz continuous wave microwave radiation and four serving as controls. Lines of constant specific absorption rate (SAR) values were measured and plotted for rabbits exposed in the chamber. The results were obtained by observation of temperature increases in the exposed rabbit carcasses by thermography. The results indicated that a peak SAR of 14 W/kg could be expected in the head of the rabbit when the animal was in the normal resting position in the cage. Four New Zealand albino rabbits weighing approximately 4 kg were exposed each day for 23 hours a day for a period of six months in the system. Periodic examination of the eyes with a biomicroscope and opthalmoscope were made and the following parameters were monitored throughout the exposure period: body weight, urinary output, rectal temperature, hematocrit, hemaglobin, white cell count with differential, platelet count, and basic blood coagulation studies. No significant differences were found between experimental and control animals. (No refs.)

4566 EFFECT OF ELECTROMAGNETIC PULSE ON AVOIDANCE BEHAVIOR AND ELECTROENCEPHALOGRAM OF A RHESUS MONKEY. (Eng.) Mattsson, J. L. (Armed Forces Radiobiology Res. Inst., Bethesda, MD 20014); Oliva, S. A. *Aviat. Space Environ. Med.* 47(6): 644-648; 1976.

A 12-kg male rhesus monkey was exposed to an electromagnetic pulse (EMP) field with pulse characteristics similar to those of industrial systems and at a field intensity and pulse rate much greater than those in typical work areas. The effect of the EMP was determined by electroencephalogram (EEG) and Sidman avoidance behavior. An EMP exposure at 266 kv/m, 5 pulses/sec was begun in the second Sidman session and ended one hour later, midway in the sixth session (18,700 pulses). During Sidman performance sessions, the monkey consistently avoided a 0.2-sec shock, administered with an interval of less than 10 sec. Sessions lasted 10 minutes with

five minute rests. No significant changes in Sidman avoidance behavior or EEG were noted. Almost all EMP energy in this study was in the frequency range below 30 MHz, where wavelengths are long. Model studies predict only minimal energy deposition when wavelengths are long relative to subject size. Also, there was a broad distribution of energy across the lower frequency so that only a small electric field existed at a specific low frequency. Future EMP experiments should consider the wavelength to body size relationship of man in an EMP field. (19 refs.)

4567 MICROWAVE-INDUCED COCHLEAR MICROPHONICS IN CATS (SYMPOSIUM SUMMARY). (Eng.) Chou, C. K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington, Sch. Medicine, Seattle, WA 98195); Guy, A. W.; Galambos, R. *J. Microwave Power* 11(2): 171-173; 1976.

Recordings of Cochlear Microphonics (CM) from cats exposed to pulsed microwave radiation fram an aperture antenna were made. Microwave pulses (10 μsec) of 918 MHz were provided by a square aperture source (13 X 13 cm) located 8 cm away from the occipital pole of the cat and were fed by the AML PH40K microwave pulse generator. A piezoelectric crystal transducer was also attached to the skull of the same cat providing acoustic stimuli by bone conduction. Upon death of the cat, the nerve responses disappeared before the CM. After several minutes, CM also disappeared, but the artifact persisted, indicating the 38 kHz oscillatory signal was a genuine physiological response. A CM produced mechanically by the piezoelectric crystal had the same frequency and duration as that produced by the microwaves. The 38 kHz CM induced by microwaves pulses appeared to be related to the size of the cat skull when compared with the 50 kHz CM of guinea pigs. This frequency is also consistent with the fact that masking noises of 50 Hz to 15 kHz did not effect the threshold of evoked responses in the medial geniculate of cats. (No refs.)

4568 MICROWAVES ACTION IN PROCARYOTIC AND EUCARYOTIC CELLS AND A POSSIBLE INTERACTION WITH X-RAYS (SYMPOSIUM SUMMARY). (Eng.) Averbeck, D. (Fondation Curie, Institut du Radium, Section de Biologie, 26, rue d'Ulm, 75005 Paris, France); Dardalhon, M.; Berteaud, A-J. *J. Microwave Power* 11(2): 143-144; 1976.

Microwaves at frequencies between 70 and 75 GHz and at a power density 5 to 100 mW/cm^2, were used to determine effects on bacterial growth and lethal and mutagenic effects in bacteria and yeast cells. A growing culture of *Escherichia coli* K 12 wildtype was exposed to microwaves No global thermal effects were observed in the power range used. In a second approach the effects of microwaves were studied at a power density of up to 100 mW/cm^2 on the survival and induction of nuclear mutations in *E. coli*. The results show that microwave irradiation for 30 minutes at frequencies between 70 and 75 HGz and at the power density of up to 60 mW/cm^2 did not induce any killing in mutant and wildtype strains. Effects of microwaves on the induction of nuclear reversions in *E. coli* and in *Saccharomyces cerevisiae* were investigated. In yeast the induction of cytoplasmire mutations were studied. The results clearly demonstrate that microwave irradiation produced no mutagenic effects. Reversion rates observed after microwave treatment were always the same as the spontaneous mutation rates. X-rays were shown to affect various targets in the cell. The sensitivity of *E. coli* cells against X-irradiation became variable when cells were treated with microwaves before or after exposure to X-rays. (No refs.)

4569 USE OF THERMOGRAPHY FOR QUANTITATION OF ENERGY ABSORPTION IN ANIMALS IRRADIATED WITH MICROWAVES (SYMPOSIUM SUMMARY). (Eng.) Bielec, M. (Centre for Radiobiology and Radioprotection, Warsaw, Poland); Szmigielski, S. *J. Microwave Power* 11(2): 152-153; 1976.

Color thermovision (AGA-680) with temperature resolution of 0.5°C was used for quantitative analysis of the amount and distribution of energy absorbed in dead and live rats irradiated with 3 GHz microwaves. Dead rats were frozen, covered with a thin layer of metacrylate, and cut alongside the longitudinal axis of the body. Both parts of the body were put together and irradiated at 3 GHz (60 mW/cm^2) under far field conditions. Thermographic analysis of the internal surface (section) was performed every 3 minutes after irradiation. Living animals (rats and rabbits) were irradiated at identical conditions, and the thermographic analysis was performed from the body surface. Both dead and living animals were irradiated in frontal (head-tail) or long-side position to the microwave antenna. The results obtained showed dependence of energy absorption and distribution depending on position of the irradiated body in the microwave field. In rats irradiated at a frontal position, the highest temperatures were found at the brain base and base of the tail, while in those irradiated the highest temperatures were found at the long-side position in chest and pelvis. "Hot" points were found both in dead and living animals and were localized in the head and chest.

4570 A COMPARATIVE PERFORMANCE STUDY OF SPACED APPLICATORS IN MICROWAVE DIATHERMY (SYMPOSIUM SUMMARY). (Eng.) Kantor, G. (Division of Electronic Products, Bureau of Radiological Health, FDA, 12721 Twinbrook Parkway, Rockville, MD 20852); Witters, D. M., Jr. *J. Microwave Power* 11(2): 164-165; 1976.

Spaced applicators in clinical use and appropriate for microwave diathermy were evaluated by comparing near field measurements of external fields in free space and in the presence of phantoms, together with resulting heating patterns. Spatial variations of the field components were mapped in the vicinity of the applicators with a miniature isotropic probe. Digital minicomputer techniques were used to map

free space and scattered fields. The results indicated that for a microwave diathermy setting of 100 W, the total free field was typically 500 mW/cm^2 (equivalent plane wave power density). It also was shown that measured scattered fields around spaced applicators loaded with phantoms of simulated fat-muscle tissue strongly depended on the relative size of applicators and phantoms and exceeded 10 mW/cm^2 (equivalent plane wave power density) for typical treatment conditions. Heating patterns of spaced applicators irradiating planar, arm, and thigh phantoms were obtained by exposing the midplane of each phantom to an infrared thermographic camera. Temperature profiles in the region of maximum intensity were obtained. For planar phantoms, the transverse fields and temperature profiles had similar shapes. Thus, for normal incidence, the longitudinal component does not significantly contribute to the heating pattern.

4571 BIOCHEMICAL CHANGES IN THE BRAIN OF RATS EXPOSED TO MICROWAVES OF LOW POWER DENSITY (SYMPOSIUM SUMMARY). (Eng.) Catravas, G. N. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014); Katz, J. B.; Takenaga, J.; Abbott, J. R. *J. Microwave Power* 11(2) 147-148; 1976.

The effects of microwaves on macromolecular constituents of the brain of Sprague-Dawley rats were investigated. Groups of rats, weighing 200-220 g, were exposed to continuous wave microwave radiation of 2450 MHz frequency and 10 mW/cm^2 power density (8 hours/day for 8 days) in an anechoic chamber. Control rats were effectively protected from the microwave beam. The microwave-induced changes in the PGE_1-stimulated brain adenyl cyclase and serotoninergic systems were determined. Preliminary results indicated an increased sensitivity of brain adenyl cyclase to PGE_1, with a shift of the dose/response curve to the left. This shift was more pronounced in irradiated animals euthanatized 8 hours post-exposure than those euthanatized immediately after exposure. However, the maximal adenyl cyclase activity did not appear to be affected. Marginal changes (increase) in the activity of tryptophan hydroxylase and levels of serotonin in the hypothalamic-thalamic region were also observed. No changes in monoamine oxidase activity were seen. (No refs.)

4572 MICROWAVE HEATING OF THE UTERINE WALL DURING PARTURITION (SYMPOSIUM SUMMARY). (Eng.) Daels, J. (Kliniek Maria Middelares, Gent, Belgium). *J. Microwave Power* 11(2):166-168; 1976.

Microwave heating of the uterine wall during parturition was carried out in a selected group of 2000 patients. The apparatus used was the Radarmed 12 S 230 with the curved Grossfeldstrahler widefield radiation electrode. Treatment was applied intermittently only during the uterine contractions. The dose administered varied between 80 and 100 mA. The results were compared with a control-group of 2000 patients whose pregnancies and deliveries were similar. Of the 2000 patients treated, 1936 described the analgesic effect as good, the remaining 64 experienced only moderate attenuation. The "transcalancy-group" required significantly less sedation than the control group. Comparison of the average duration of the dilation stage revealed a significant shortening of the average duration of the dilation period in those receiving microwave transcalency: 108 minutes for primiparae and 43 minutes for muliparae. This acceleration was localized mainly in the latent phase. No side-effects of microwave heating of the tissues were observed. After intermittent microwave transcalency, temperature of the amniotic fluid never exceeded 36.5°C. The temperature of the newborn was slightly increased but never exceeded 37.8°C. (No refs.)

4573 PACEMAKER INTERFERENCE: A LOW RISK. (Eng.) Anonymous. *Med. World News* 17(17): 40; 1976.

It has been publicized that electromagnetic radiation (i.e., from microwave ovens) may interfere with the operation of cardiac pacemakers. Experts, however, feel that the chances of such an occurrence are rare and would seldom be fatal. The R-wave-inhibited demand pacemaker, used in about 90% of recent implants, operates by stimulating the heart if an R-wave is not detected. This device is susceptible to electromagnetic interference (EMI), which may cause the heart to skip a beat, temporarily "control" the heart, or stop it. Moving away from the EMI source remedies the situation. Recently, manufacturers have designed better shielding and filtering circuits to minimize the risk. FDA, Biomedical Engineer, J. R. Veale, feels the risk of EMI of pacemakers is low, except in some work areas where 15-20% of pacemaker wearers under age 60 come into contact with high powered electrical equipment. Automobile mechanics may have their pacemakers stop within a foot of a well-tuned operating Volkswagen engine. It is suggested by Veale, that employers warn pacemaker wearers of the potential EMI of pacemakers and be aware of the electromagnetic radiation levels of their equipment. Dr. Doris Escher, a cardiologist at the Albert Einstein College of Medicine does not feel the risk of EMI is great, but suggests caution to pacemaker wearers when using electrical equipment. (No refs.)

4574 AN INVESTIGATION OF THE USE OF MICROWAVE RADIATION FOR PULMONARY DIAGNOSTICS. (Eng.) Pedersen, P. C. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112); Johnson, C. C.; Durney, C. H.; Braggs, D. G. *IEEE Trans. Biomed. Eng.* 23(5): 410-412; 1976.

A new technique is described in which penetrating microwave radiation was used for the diagnosis and monitoring of pathologic cardiopulmonary conditions,

such as, pulmonary edema. Edema was shown to cause changes in the electromagnetic characteristics of the lung tissue, which in turn produced a change in the reflected and transmitted microwave radiation. Both the amplitude and phase changes of the microwave signals were measured and correlated with lung volume. (5 refs.)

AUTHORS OF CURRENT LITERATURE INDEX